RATE STRUCTURE OF CANADIAN FOR-HIRE TRUCKING

Effects of Economic Regulation

by

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Research Branch
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November 1982

Version française disponible sous le titre
"La structure des taux dans l'industrie
canadienne du camionnage pour compte d'autrui:
Effets de la réglementation économique", rapport n° 1983/02F

First Printing, July, 1983

Canadian Transport Commission
15 Eddy St., 15th floor, Ottawa-Hull K1A 0N9

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Catalogue Number TT72-1983/02E
ISBN 0-662-12667-X

Printed in Canada

Commission canadienne des transports | Canadian Transport Commission

FOREWORD

This study examines the impact of economic regulation on the level and structure of rates in the Canadian for-hire trucking industry. The study was prepared by Ms. V. Wei of the Research Branch of the Canadian Transport Commission. It complements a previous research report on cost structure carried out by Dr. M.B. Cairns and Mr. B.D. Kirk and published by the Canadian Transport Commission during 1980.

The diversity of rate and entry regulations between provinces in Canada allows a comparison of trucking rate structures between the unregulated intraprovincial sector of the industry in Alberta and the regulated sectors in Québec and Ontario. In analyzing the regulatory impact on trucking rates, the study concentrates on differentials in rate levels between regulated and unregulated environments and aspects of rate structure, namely, value-of-service pricing, cross-subsidization, and trucking rates for shipments to and from small communities. In the study, econometric models are developed for examining the above issues.

Evidence presented in this report indicates that economic regulation has in various cases affected the rate structure of the trucking industry. However, there is no consistent and significant difference in the level of rates between regulated and unregulated sectors of the industry.

This report is being released as a contribution to knowledge concerning the impact of regulation on the rate structure of the Canadian for-hire trucking industry. The views expressed in this report, however, are those of the author and not necessarily those of the Canadian Transport Commission.

Jean Dubé
Vice-President (Research)

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ACKNOWLEDGEMENTS

The study was initially undertaken by Dr. M.B. Cairns and Mr. B.D. Kirk. Dr. Cairns performed the preliminary data analysis and prepared Chapter 4, while Mr. Kirk carried out the assignment of population counts. The author is greatly indebted to them for their initial guidance and helpful comments. The author would also like to acknowledge the helpful comments from Dr. G. Hariton and Messrs. J. Diamond, B.F. Kelso and A. Ray, of the Research Branch. Thanks also go to Mr. R. Hakka, Ms. M. Taylor, and Ms. H. Dempsey and Mr. P. Levasseur who both edited the text, and the staff in Word Processing and EDP Support, Canadian Transport Commission.

The views expressed in this report are, however, those of the author and do not necessarily reflect the views of the Canadian Transport Commission.

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Chapter 1

INTRODUCTION

This study examines the effects of regulation on the level and structure of rates in the for-hire trucking industry. It is related to the results of a previous Canadian Transport Commission Research Branch report* on the cost structure of the for-hire trucking industry.

In recent years, there has been growing concern regarding government regulation of the private sector. In the trucking industry, the debate over economic regulation has intensified as indicated by the regulatory changes taking place in the United States and the assessments of truck transportation undertaken within the Canadian Federal, and a number of provincial, governments.

1.1 Objectives

The main objective of this study is to investigate, by empirical analysis, various issues related to the regulatory impact on trucking rates. In particular, the issues examined are price discrimination, rate differentials between regulated and unregulated environments, cross-subsidization and the small community problem.

Price discrimination in the trucking industry can be defined from both single and multi-output points of view. From a single-output point of view, price discrimination means that carriers charge different prices for different shipments which are homogeneous as far as the transportation service required is concerned. An example of this is when rates for shipments with the same weight, distance and transportation costs are different. From a multi-output point of view, price discrimination implies that the differences in prices do not reflect a proportional difference in marginal costs between traffic segments. The type of price discrimination examined in this study is the value-of-service pricing which deals with single-outputs. Specifically, value-of-service pricing occurs when, other things being equal, motor carriers charge higher rates for shipping high-value commodities than for low-value commodities. This is not uncommon in transportation industries. However, questions arise as to whether the entry control on motor carriers has enabled trucking firms in a regulated province to

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* M.B. Cairns and B.D. Kirk, Canadian For-Hire Trucking and the Effects of Regulation: A Cost Structure Analysis, CTC Report No. 10-80-03.

exercise more price discrimination than those in an unregulated province. The present study investigates this issue.

The second issue relates to the difference in price levels between regulated and unregulated environments. In order to compare trucking rates in different regulatory environments, analyses of the level and structure of trucking rates in Alberta, Ontario and Québec were performed. Alberta represents an unregulated environment or "competitive market" for the motor carriers. While Ontario and Québec both have entry and rate regulations, Ontario's rate control is less stringent than Québec's. The other provinces were excluded from the above mentioned trucking cost structure analysis due to data limitations.

The third issue deals with the cross-subsidization between large and small shipments. Cross-subsidization is defined as some shipments carried at rates below marginal costs and subsidized by other shipments moving at rates above marginal costs. In other words, carriers use excess profits generated from some traffic to compensate for losses from other traffic.

Finally, the small community issue concerns the controversy over whether for-hire trucking services to small communities will deteriorate or whether shipments to and from small communities will be subject to much higher rates in a de-regulated environment than in a regulated one.

Throughout the study, the revenue per ton-mile is used as a proxy for rates. However, the actual rate schedules adopted by motor carriers may differ. For example, the rate unit may be in terms of per hundred weight, per mile, per ton, per trip, etc. Nevertheless, since the purpose of this study is to compare the cost of transport to different shippers, a uniform measure such as revenue per ton-mile is not inappropriate.

A secondary objective of this study is to assess the importance of sample design in the econometric modelling of the structures of trucking rates, because trucking shipment data is obtained from a complex survey.

1.2 Data and Methodology

The primary data source used in this study is the 1975 For-Hire Trucking Origin and Destination Survey. However, for purposes of modelling, the shipment records obtained from the survey are expanded to include the following additional information: (i) estimated long-run average cost per ton-mile for the carriers included in this study and (ii) estimates of the population of the origin and destination of the shipments.

In a preliminary data analysis, the method of principal component analysis is used to develop measures which can be used to summarize or describe characteristics of trucking services by

provinces and by commodity groups. Later, in the econometric analysis, the study adopts both the Weighted Least Squares (WLS) and the Ordinary Least Squares (OLS) methods in modelling. The results of the two methods are compared, and the results of the former method are selected for analyzing the impact of economic regulation on trucking rates.

Following this introduction, Chapter 2 presents a general summary of the results of this study. Chapter 3 provides a background on the regulations of motor carriers as well as a review of studies on economic regulation and its effect on the level and the structure of for-hire trucking rates. Chapter 4 presents the results of detailed data analysis, including the principal components analysis, and discusses the alternative methods to be used in formulating econometric models. Finally, Chapter 5 presents the empirical results of this study.

Chapter 2

GENERAL SUMMARY AND CONCLUSIONS

The diversity of rate and entry regulations between provinces in Canada allows an assessment of the impact of economic regulation of motor carriers. In fact, several existing studies have used econometric analysis to examine the differences in the level and the structure of trucking rates between regulated and unregulated provinces. However, for two main reasons, work to date has not provided strong evidence of either the merits or demerits of regulation. Firstly, Statistics Canada's For-Hire Trucking Survey (TOD), which is the only information source of shipment level data available in Canada, is based on a complex sampling design where sample units do not have an equal probability of being selected; consequently, the results of regression analysis may be biased towards the shipments of larger carriers. Secondly, the significant variation of traffic mix in different provinces has made it very difficult to determine the real impact of regulation on the structure of trucking rates. Therefore, this study has made several attempts to improve upon the methodologies used in the previously published empirical analyses. First, the Weighted Least Squares method is used to take into account the sample design of TOD data. Second, separate regression models are developed for different provinces and for different types of traffic in order to reflect the differences in rate structure between provinces and between groups of shipments. Finally, some cost information obtained from the earlier study of the cost structure of Canadian for-hire trucking is used to standardize the individual carrier differences in the rate models so that rate level comparisons between provinces can be made.

The following are major conclusions and observations of this study:

(a) The empirical results show that the value of commodities has some effect on trucking rates. Not surprisingly, higher rates tend to be associated with high-value commodities. While in most cases rate differentials between high and low-value commodities exist in Québec, Ontario and Alberta, these appear to be greater in regulated Québec and Ontario than in unregulated Alberta. This conclusion, however, is based on two assumptions. One is that the traffic mix at the three-digit SCC code level is homogeneous in the three provinces and the other is that the cost differentials between high and low-value commodities in the three provinces are similar.

(b) The study found no evidence that average revenues per ton-mile earned by carriers in Québec and Ontario are consistently higher than those earned by carriers in Alberta. According to the rate level analysis, the rank orders of provinces in terms of highest revenue per ton-mile vary considerably over different weight and distance ranges. Furthermore, the rank orders of provinces in rates are generally consistent with the results in the trucking cost study by Cairns and Kirk (1980).

(c) The analysis of the rate differentials between intra and interprovincial shipments also indicates that in Alberta the rates on intraprovincial shipments which are not regulated are not significantly different from the rates charged by interprovincial carriers who are subject to entry regulation. In Ontario and Québec, where both intra and interprovincial motor carriers are regulated, rate differentials between these two market segments are found to be insignificant in Ontario, but significant in the Québec Less Than Truckload (LTL) shipments. In the latter case, rates on LTL interprovincial shipments are found to be much lower than intraprovincial shipments.

(d) The issue of cross-subsidization between large and small shipments is examined separately for truck-load (TL) and LTL markets. For LTL, the variations of rates in relation to shipment weights in Québec and in Alberta are similar, while in Ontario a different pattern appears. The empirical results suggest that in Ontario, small LTL shipments tend to be subsidized by large LTL shipments. In TL total traffic, the Ontario rate curve is also less elastic in response to changes in shipment weights than the rate curves of the other two provinces. However, in TL commodity groups, only the result of the Québec "end product" commodity group shows a clear sign of cross-subsidization between small and large shipments; in this case, the result indicates that large TL shipments might be subsidized by small TL shipments.

(e) On the small community issue, economic regulation appears to have some impact on the rate differentials between small and large communities; the effect of population on rates in Alberta is quite different from the effects measured in Québec and Ontario.

(f) The study indicates that the WLS method could be an alternative to the OLS method for use on data from a complex sample survey. In fact, for the majority of the TOD data groups studied, the Weighted Least Squares method fits better in terms of the percentage of explained variations.

Overall, economic regulation is one of the many exogenous variables that affect trucking rates. Regional, social and economical conditions as well as Tariff Bureaux activities may also cause different rate structures between provinces. These may in some cases offset, while in other cases enhance, the rate differentials created by regulation.

Chapter 3

BACKGROUND

3.1 Regulatory Environments

In this chapter, the nature of the economic regulation of for-hire trucking firms in Canada is discussed; the emphasis is on comparisons of regulation between the provinces of Alberta, Ontario and Québec. More detailed discussions about regulations of the Canadian for-hire trucking industry are contained in three previous studies published by the CTC.*

The provincial regulatory agencies are responsible for most of the regulation of for-hire trucking in Canada; the Canadian Transport Commission exercises some control over Sunday trucking operations and some mergers and acquisitions by extra-provincial carriers.

Because provincial boards independently regulate trucking firms operating in their respective provinces, different approaches to regulation have developed. However, these differences are mainly in the degree of strictness of control rather than in the content of economic regulation. Generally speaking, economic regulation takes the form of control over entry, rates, mergers and acquisitions. Also, non-economic regulation is imposed on carriers. Such regulations include requirements for bills of lading, control of vehicle sizes and weights, imposition of speed limits, and rules regarding the transport of dangerous goods. The following paragraphs discuss the nature of entry and rate controls.

3.1.1 Entry Control

Entry control is the most important form of economic regulation exercised by the provinces. In order to obtain authority to provide service, new firms are required to meet a test of "public convenience and necessity" which is imposed by provincial regulatory boards. However, it is in defining these terms, that the difference in strictness of control among provincial regulatory bodies becomes apparent. After the regulatory board's approval of an entry application, an operating licence or certificate is usually issued. In granting

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* These are: The Alberta Trucking Industry, Economic Analysis of Regulations Governing the Trucking Industry in Québec, and Canadian For-Hire Trucking and the Effects of Regulation: A Cost Structure Analysis. For references, see bibliography.

such licences, the regulatory agency may also specify operating restrictions related to the commodities, routes, points, and areas to be served.

Of the three provinces examined in this study, Alberta does not exercise any economic control over intraprovincial trucking. Although for-hire carriers must obtain a certificate or licence from the Alberta Motor Transport Board, this licence is not difficult to obtain and therefore does not constitute an entry barrier. However, for Alberta interprovincial operating licences, the applicants are required to meet more strict entry requirements, such as, showing proof of demand for the proposed services. In Ontario and Québec, entry into the for-hire trucking industry is regulated. Both the Ontario Highway Transport Board and the Québec Transport Commission issue operating permits based on the requirement of "public convenience and necessity". There is no discernible difference in the strictness of entry control between Québec and Ontario.

3.1.2 Rate Control

There are several types of rate controls practised by provincial Motor Carrier Boards. These are: rate prescription, rate filing and approval, and rate filing only. In Canada, only Manitoba and Saskatchewan prescribe rates. In both provinces, the tariffs established by the boards are not cost-based. The Manitoba Highway Transport Board adopts a weight-distance-density tariff, while Saskatchewan prescribes a class-based tariff, partially modified to incorporate both minimum and maximum rates. In provinces where rate approval is required, the regulatory agency may amend the rates filed by carriers or conduct public hearings to decide whether the rates are uneconomic, unreasonable or unjustly discriminatory. However, in the majority of cases, rates are approved.

The Alberta Motor Transport Board does not impose any form of rate control over carriers operating in that province. The Ontario Highway Transport Board requires only rate filing. The Québec Transport Commission approves and may amend rates filed by carriers.

3.2 Impact of Regulation on Trucking Rates

Since the early 1970's, a large body of literature on the subject of the need for and the criticism of the economic regulation of truck transportation has been published. Most of this literature has been published in the United States and is related to U.S. motor carrier regulatory reform.* In Canada,

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* A detailed list of literature can be found in the article by D.V. Harper, Entry Control and the Federal Motor Carrier Act of 1980, (Transportation Law Journal, Vol. 12, 1980).

studies have been conducted in an attempt to measure the impact of economic regulation on the level and the structure of trucking rates. More recent studies include the work of Maister (1977), and McRae and Prescott (1978). The present study has similar objectives and tests most of the same hypotheses, but takes a different approach.

The arguments for and against economic regulation of the trucking industry are mainly based on different viewpoints regarding the existence of economies of scale, the degree of competition in the for-hire trucking industry and the need to protect small shippers and small communities. Initially, when the economic regulation was first imposed on motor carriers, the main purpose of the legislation was to protect existing carriers from "destructive" competition. Recently, the defenders of economic regulation have placed more emphasis on the need for entry and rate controls to protect the shipper from monopoly pricing and the deterioration of services.

Whether or not the trucking industry has a tendency toward concentration and monopoly pricing depends on its scale economies. Cairns and Kirk (1980) have studied the potential of concentration in the Canadian for-hire industry by analyzing the cost structure and the scale economies of the industry in three provinces. The study concludes that scale economies do exist in the trucking industries of Alberta, Québec and Ontario. Therefore, it rebuts the argument of the anti-regulation group that the returns to scale in trucking are constant, therefore, economic regulations only result in high transportation prices. On the other hand, it rejects the viewpoint for regulation that economic regulation prevents concentration since the tendency toward industry concentration in unregulated Alberta is no greater than regulated Québec and Ontario. Overall, the study is neutral on the subject of the impact of economic regulation on the cost structure and the scale economies of the trucking industry.

In this study, the issue of monopoly pricing and the impact of economic regulation is examined by comparing the rate levels of for-hire trucking industries in different regulatory environments. It is worth noting that many trucking firms set rates collectively through Tariff Bureaux which exist in both regulated and unregulated provinces. These rate-making bodies may have reduced or complicated the rate differentials that theoretically should occur between regulated and unregulated markets. However, the role of Tariff Bureaux in setting trucking rates is not analyzed in this study. A detailed analysis of the impact of Tariff Bureaux is contained in a study recently published by Transport Canada.*

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*J. McRae and D. Prescott, An Analysis of the Role of Tariff Bureau Members in Less-than-Truckload Market, Transport Canada, April 1981.

Another issue related to the monopoly power of carriers is price discrimination. While price discrimination may take several forms, this study analyzes only the value-of-service pricing in the trucking industry where commodities of greater value incur higher rates. It has been asserted that entry and route restrictions enhance carriers' abilities to price discriminate. Therefore, value-of-service pricing should be more pronounced in a regulated rather than in an unregulated environment. In Chapter 5, this hypothesis is assessed.

Economic regulation of transportation is sometimes used as a means to ensure that certain services are provided below cost and are cross-subsidized by excess profits generated from more lucrative traffic. The hypothesis that cross-subsidization between large and small size shipments generally exists in the trucking industry is examined.

Finally, there is the issue of whether shippers in small communities will face substantially higher prices for transportation service or suffer a deterioration of service in the absence of economic regulation. This study compares the average rates on shipments to and from different size communities on the basis of the same weight, distance and other fixed shipment characteristics.

Chapter 4

PRELIMINARY DATA ANALYSIS AND THE GENERAL MODEL FORMULATION

This chapter presents a brief description of the data sources used in this study and provides a preliminary statistical evaluation of the truck shipment data that forms the basis for subsequent analysis of the level and structure of rates. The general econometric model used in the analysis of the level and structure of rates is also presented.

4.1 Data Sources

The primary data source used in this study was a computer tape compiled by Statistics Canada from the 1975 For-Hire Trucking Origin and Destination Survey (TOD). At the time this study was launched, the most recent data available was from 1977. However, the 1975 data was used instead because of the attempt to include 1975 trucking cost estimates derived by Cairns and Kirk in the explanatory variables for trucking rate models. The TOD survey is a survey of shipment invoices maintained at Document Storage Location Points (DSLP), for a sample of truck carriers. Information on origins and destinations of shipment, commodities carried, weight of goods and revenue received is recorded. Altogether, there was usable data for 137 151 shipments carried during 1975.*

Shipment costs are not recorded for the TOD survey and are generally not available. However, from the earlier study of the cost structure of Canadian for-hire trucking, it is possible to estimate long-run average costs per ton-mile for the carriers included in that study; these long-run average costs take into account differences between individual carriers in the level of trucking output, the input prices of labour, fuel, purchased transportation and capital and the level of capacity utilization.** Therefore, although these costs were not a precise reflection of individual shipment costs, it was decided to use these long-run average costs for individual carrier differences.

Altogether, long-run average costs were estimated for 103 carriers in the provinces of Québec, Ontario and Alberta, based on a sample of 23 560 shipments taken from the total of 137 151 shipments which were associated with these carriers.

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* Details of the sampling methodology used for the TOD survey appear in M.B. Cairns and B.D. Kirk, op. cit. pp. 221-226.

** Ibid.; Chapter 7 contains a thorough description of how these long-run average costs were estimated.

Attention was therefore restricted to these 23 560 shipments and each shipment record was expanded to include the estimated long-run average cost per ton-mile of the carrier associated with that shipment. In order to analyze the small community issue, each shipment record was further expanded to include estimates of the population of the origin and the destination of the shipment; details of the assignment of these population counts appear in Appendix A.

4.2 Preliminary Data Analysis

Table 4.1 presents the number of shipments by province, commodity group and type of service for the 23 560 shipments under investigation. The commodity groups are those defined by Statistics Canada* (strictly speaking they are referred to as sections) and are as follows:

Commodity Group	Description
I	Live animals
II	Food, feed, beverages and tobacco
III	Crude materials, inedible
IV	Fabricated materials, inedible
V	End products, inedible
VI	General or unclassified freight**

The types of service categories of a shipment are as follows:

(i) LTL: Shipments less than 15 000 lbs.

(ii) TL short-haul: Shipments in excess of 15 000 lbs. moving less than 500 miles.

(iii) TL long-haul: Shipments in excess of 15 000 lbs. moving more than 500 miles.

The use of these three types of service categories was based upon empirical analysis of traffic characteristics conducted in the earlier cost structure study.***

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* Statistics Canada 12-502, Standard Commodity Classification Manual, (Vol. 1, Revised 1972).

** It should be emphasized that this group represents generally unclassified freight shipments and does not correspond to the commodities carried under a General Freight Licence which usually belongs to commodity groups other than group VI.

*** M.B. Cairns, and B.D. Kirk, op. cit. pp. 90-102.

Table 4.1

NUMBER OF SHIPMENTS BY PROVINCE, COMMODITY GROUP AND TYPE OF SERVICE

Province	Type of Service	Commodity Group						Total
		I	II	III	IV	V	VI	
Québec	LTL	91	370	53	1 070	1 649	261	3 494
	TL short-haul	201	621	224	2 007	298	17	3 368
	TL long-haul	1	9	2	78	15	3	108
	Total	293	1 000	279	3 155	1 962	281	6 970
Ontario	LTL	88	813	6	345	738	228	2 218
	TL short-haul	134	1 190	682	2 774	357	65	5 202
	TL long-haul	4	47	16	146	5	2	220
	Total	226	2 050	704	3 265	1 100	295	7 640
Alberta	LTL	32	285	27	490	1 080	27	1 941
	TL short-haul	414	965	1 586	2 710	482	3	6 160
	TL long-haul	3	205	67	519	55	0	849
	Total	449	1 455	1 680	3 719	1 617	30	8 950

Examination of Table 4.1 reveals that commodity groups II, IV and V are the largest groups represented in the sample, while shipments from group VI are virtually absent in Alberta. Clearly, the relatively small number of shipments belonging to group VI in all three provinces makes provincial comparisons with respect to that group very uncertain; consequently, group VI shipments were excluded from further analysis. Table 4.1 also reveals that of the three types of service, TL long-haul is the least common in all three provinces, while TL short-haul is the predominant service in Ontario and Alberta, LTL service is the largest in Québec followed closely by TL short-haul. When considering shipments by commodity group and type of service jointly, it can be seen that the type of service is related to the commodity group; in all the provinces, commodities in groups I to IV are predominantly carried as TL short-haul, while commodities in group V are predominantly carried as LTL.

Table 4.2 presents the revenue (¢) per ton-mile by province, commodity group and type of service for the same 23 560 shipments.

Table 4.2

REVENUE (¢) PER TON-MILE BY PROVINCE, COMMODITY GROUP AND TYPE OF SERVICE

Province	Type of Service	Commodity Group I	II	III	IV	V	VI	Total
Québec	LTL	17	19	9	23	30	37	26
	TL short-haul	14	5	8	4	10	9	5
	TL long-haul	3	6	6	4	8	4	5
	Total	14	5	8	5	17	11	6
Ontario	LTL	20	10	4	15	21	15	16
	TL short-haul	11	7	4	6	6	6	6
	TL long-haul	6	4	3	4	3	5	4
	Total	11	7	3	6	11	8	6
Alberta	LTL	11	9	7	17	16	14	15
	TL short-haul	6	4	4	5	7	15	5
	TL long-haul	9	5	2	4	6	-	4
	Total	6	5	4	5	8	15	5

These figures represent average revenues per ton-mile having been calculated as the ratio of total revenue over total ton-miles for each corresponding cell in the table. It is immediately apparent that while provincial revenues per ton-mile are similar, considerable variation exists in revenue per ton-mile by commodity group and type of service. Generally speaking, the highest revenues per ton-mile are generated by shipments of commodities in group V, while the lowest revenues per ton-mile correspond to shipments of commodities in group III. Moreover, considerable differences exist in revenues per ton-mile by type of service; LTL revenues per ton-mile are approximately three times the revenue per ton-mile for TL shipments in Ontario and Alberta and approximately five times in Québec.

Overall, it is apparent that in the subsequent analysis of the level and structure of rates, careful account should be taken of differences in commodity and type of service when making provincial comparisons. Shipment weight and distance are quantitative variables and may readily be included in any econometric model. However, commodity classification is a qualitative variable and so differences are more appropriately accommodated by partitioning shipments into homogeneous groups and modelling each independently rather than including a large number of commodity dummy variables in a single model.

The question of what constitutes a homogeneous group of commodities is, however, ambiguous. The six groups defined above may be further disaggregated according to the three-digit Standard Commodity Classification (SCC) code; the most frequently occurring three-digit SCC codes and their descriptions appear in Table 4.3 by province. Examination of the table reveals that group I (Live Animals) consists of poultry in Québec, swine in Ontario and cattle in Alberta with almost no overlap between provinces. In group II (Food, Feed, Beverages and Tobacco), the predominant commodities in Québec and Ontario are dairy products and other food preparations which are virtually non-existent in Alberta where, instead, cereal grains constitute the single largest commodity. The pattern of distinct commodities by province continues with the remaining three groups: crude mineral oil, gasoline, engines and turbines and passenger automobiles and chassis are almost exclusive to Alberta; wood pulp is exclusive to Ontario. Finally, other chemical specialities and trailers and semi-trailers constitute significant movements in Québec and Ontario while being virtually absent in Alberta.

At this point it should be emphasized that these differences by province reflect only the activities of the sample of carriers under consideration. Moreover, the absence of significant movements of a commodity by truck within a province does not preclude the possibility that significant movements of the commodity take place by some alternative mode. In summary, it is apparent that a wide diversity of commodities

Table 4.3

NUMBER OF SHIPMENTS BY PROVINCE FOR THE MOST FREQUENTLY OCCURRING COMMODITIES

Commodity Group	3-Digit SCC Code	Commodity Name	Number of Shipments			PCA Symbols
			Québec	Ontario	Alberta	
I	001	Cattle	0	34	414	1
	003	Swine	0	191	21	2
	006	Poultry	277	0	5	3
	Other		16	1	9	*
II	011	Meat, fresh chilled or frozen	61	2	79	1
	051	Dairy products	282	259	17	2
	061	Cereal grains, unmilled	43	83	647	3
	064	Other bakery products	15	109	206	4
	091	Vegetables, fresh or chilled	22	399	51	5
	146	Other food preparations	353	378	93	6
	172	Fermented alcoholic beverages	16	321	17	7
	Other		208	499	345	*
III	212	Oil seeds, oil nuts and oil kernels	5	32	271	1
	262	Crude mineral oils	0	0	226	2
	276	Sand, gravel and crude stone	114	522	389	3
	279	Other crude non-metallic minerals	100	79	691	4
	Other		60	71	103	*
IV	331	Lumber and sawn timber	562	14	501	1
	341	Wood pulp	169	3	0	2
	415	Explosives, fuses and caps	193	1	132	3
	429	Other chemical specialities, industrial	154	587	30	4
	431	Gasoline	4	17	750	5
	432	Fuel oil	236	74	280	6
	439	Petroleum and coal products	124	365	153	7
	475	Cement and concrete basic products	246	675	547	8
	Other		1 467	1 529	1 326	*
V	502	Engines and turbines	5	1	197	1
	581	Passenger automobiles and chassis	0	0	379	2
	583	Trucks, truck chassis and truck tractors	4	2	159	3
	584	Trailers and semi-trailers	476	170	9	4
	588	Motor vehicle engines and accessories	167	29	87	5
	741	Household furniture	127	21	21	6
	945	Other end products not classified by material	173	42	11	7
	951	Shipping and distribution containers	40	410	51	8
	Other		970	425	703	*

exist, particularly within commodity groups IV and V, and that the pattern of traffic characteristics is significantly different by province.

In order to determine whether the diversity of commodities within groups resulted in any significant clustering of shipments by commodity, a principal component analysis was conducted on selected financial and traffic related operating characteristics. For each shipment in the three provinces and the five commodity groups, the following financial and traffic related variables were recorded:

y_1: Shipment revenue per ton-mile (REV)

y_2: Long-run average carrier cost per ton-mile (COST)

y_3: Shipment weight (WT)

y_4: Shipment distance (DIST)

y_5: Population of the origin of the shipment (OPOP)

y_6: Population of the destination of the shipment (DPOP)

y_7: Month of shipment (MONTH)

These seven variables were selected in order to permit the differentiation of shipments by transit characteristics, type of carrier and by service requirements as reflected in the rates charged.

The technique of principal component analysis is a general statistical technique which was used in analyzing the service characteristics of shipments by province and commodity group in order to identify unusual or outlying shipments, to reveal any natural clustering of shipments by three-digit SCC codes and to determine the extent of differences in service characteristics between provinces within the same commodity group. Details of the technique, reproduced in part from the earlier report, appear in Appendix B together with some of the results.

The coefficients of the first two principal components for the shipments in Québec, Ontario and Alberta, consisting of commodities in group 1 (Live Animals), appear in Table 4.4 and the corresponding principal component plots appear in Figures 4.1, 4.2 and 4.3 respectively. Each point represents an individual shipment. Shipments corresponding to different three-digit SCC codes are distinguished by the use of different symbols; these symbols are detailed in the last column of Table 4.3.

Shipments of Live Animals in Québec with larger values of the first principal component are moved by low cost carriers to destinations with small populations and the weights of the shipments are generally large. Furthermore, shipments of Live Animals in Québec with larger values of the second principal component generate high revenues per ton-mile and move over short distances. The percentage of variation depicted by the first two principal components was a significant 73%; examination of Figure 4.1 reveals that there are two distinct clusters of shipments. All the shipments in the large cluster are shipments of poultry while all but one of the shipments in the smaller cluster consist of 'other' commodities. A detailed examination of the computer file revealed that the shipments of 'other' commodities were all shipments of live fish. It is apparent, therefore, that for Live Animal shipments in Québec there is a significant difference in service characteristics according to the type of commodity; poultry are generally moved in large shipments by low cost carriers to destinations with small populations while fish are moved in small shipments by high cost carriers to destinations with large populations.

For shipments of Live Animals in Ontario and Alberta, the percentage of explained variation depicted by the first two principal components was 52% and 49%, respectively. The coefficients of the first principal component suggest that diversification among Live Animal shipments in Ontario and Alberta may be characterized by the extent to which the shipments generate a high revenue per ton-mile moving over short distances. Similarly, the coefficients of the second principal component indicate that diversification in both provinces is a function of shipment weight; more particularly in Alberta the population of the shipment origin is also an important factor. Examination of Figure 4.2 for Ontario reveals a small marginal cluster of cattle shipments and a predominant cluster of shipments of swine. Examination of Figure 4.3 for Alberta reveals a predominant cluster of shipments of cattle with a few outlying shipments associated primarily with the movement of poultry.

Overall, it is apparent that shipments of Live Animals in Québec, Ontario, and Alberta, consist predominantly of poultry, swine and cattle, respectively. Moreover, differences in the type of commodity within a province do lead to significant differences in service characteristics as indicated by the appearance of outlying shipments and significant clusters of shipments by commodity type.

The detailed results of applying the technique of principal component analysis to shipments in Québec, Ontario and Alberta, consisting of commodities in groups II through V, appear in Appendix B. These generally confirm the results of the analysis of group I shipments and suggest that differences in the type of commodity within a province do lead, in specific instances, to significant differences in service characteristics.

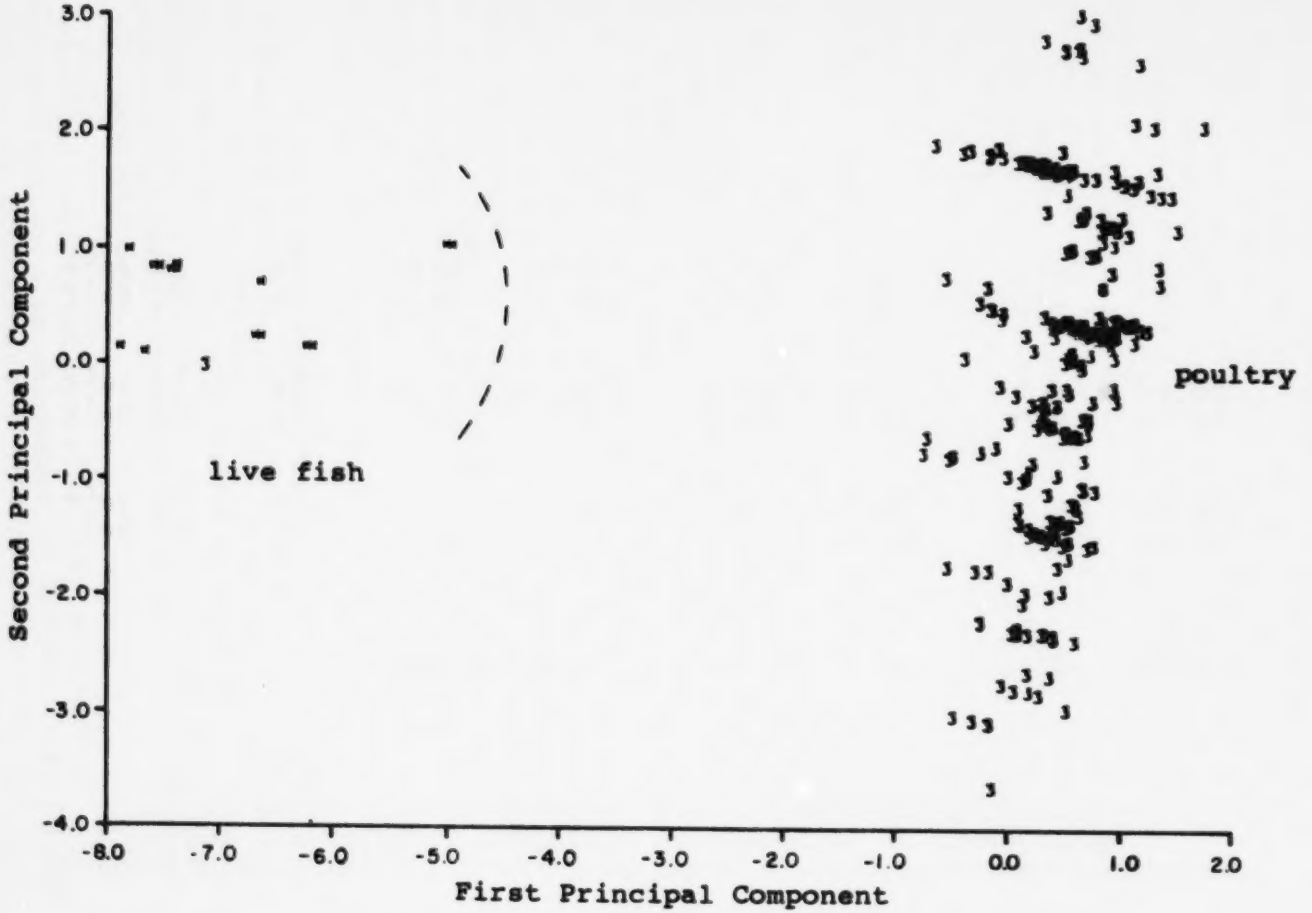
Table 4.4

COEFFICIENTS $\{a_{1i}\}$ AND $\{a_{2i}\}$ OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE ANALYSIS CONDUCTED ON SHIPMENTS OF COMMODITIES IN GROUP I (LIVE ANIMALS) WITHIN THE THREE PROVINCES

			(REV) Y_1^*	(COST) Y_2^*	(WT) Y_3^*	(DIST) Y_4^*	(OPOP) Y_5^*	(DPOP) Y_6^*	(MONTH) Y_7^*
Québec	λ_1=3.23	Z_1	0.06	-0.54	0.50	-0.29	-0.26	-0.53	0.16
n=293	λ_2=1.91	Z_2	0.70	0.06	-0.10	-0.61	0.35	0.06	-0.07
Ontario	λ_1=2.31	Z_1	0.57	0.15	-0.14	-0.56	0.25	-0.51	0.05
n=226	λ_2=1.30	Z_2	-0.14	-0.33	0.69	-0.22	0.34	-0.08	-0.47
Alberta	λ_1=2.01	Z_1	0.61	0.46	-0.30	-0.53	-0.06	0.02	0.19
n=449	λ_2=1.41	Z_2	0.09	0.02	-0.57	0.37	0.68	-0.27	0.05

Figure 4.1

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 293 SHIPMENTS IN QUÉBEC CONSISTING OF COMMODITIES IN GROUP I (LIVE ANIMALS)



Note: The symbols used in this figure and the next two (4.2, 4.3) are listed in Table 4.3 under the PCA symbols.

Figure 4.2

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 226 SHIPMENTS IN ONTARIO CONSISTING OF COMMODITIES IN GROUP I (LIVE ANIMALS)

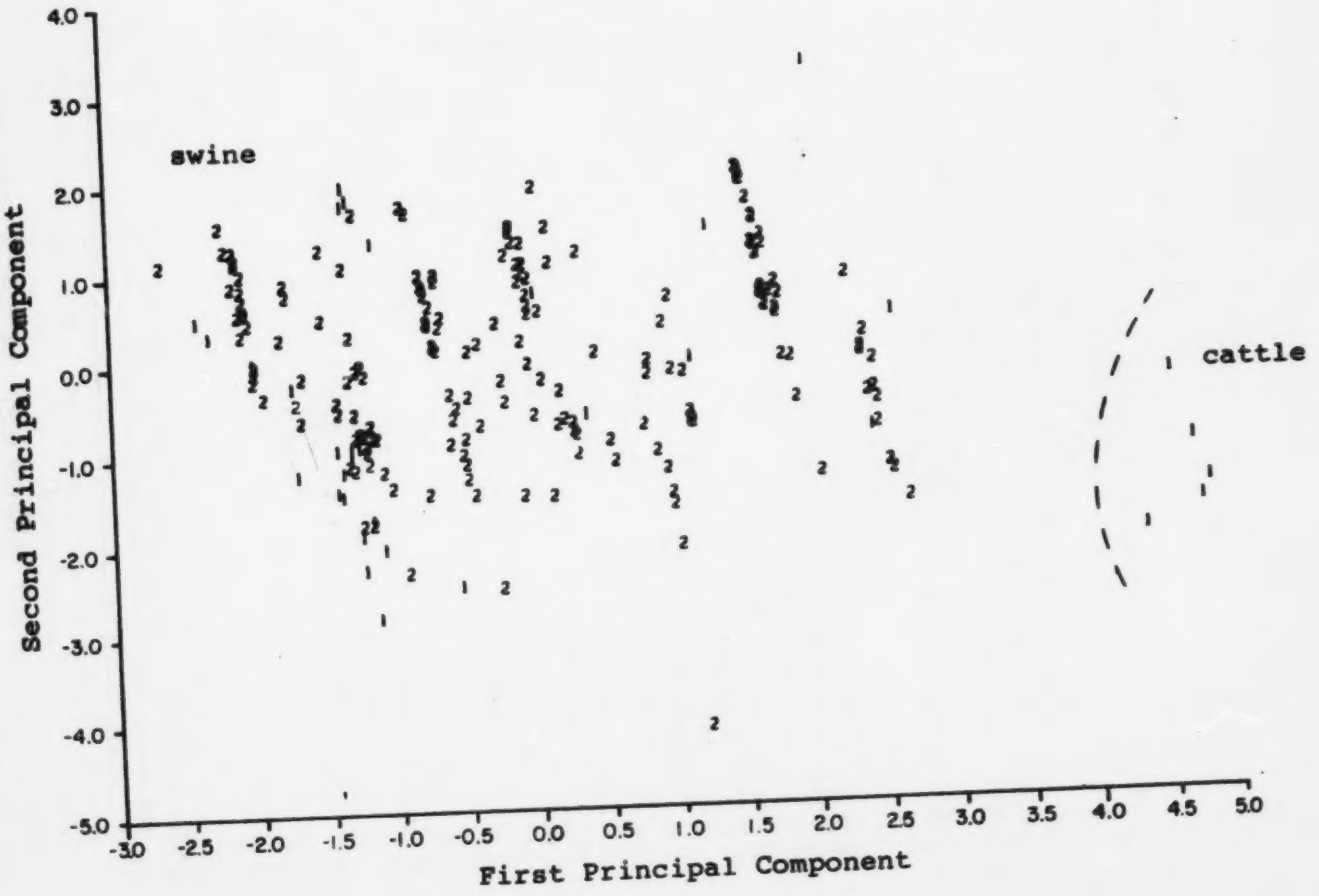
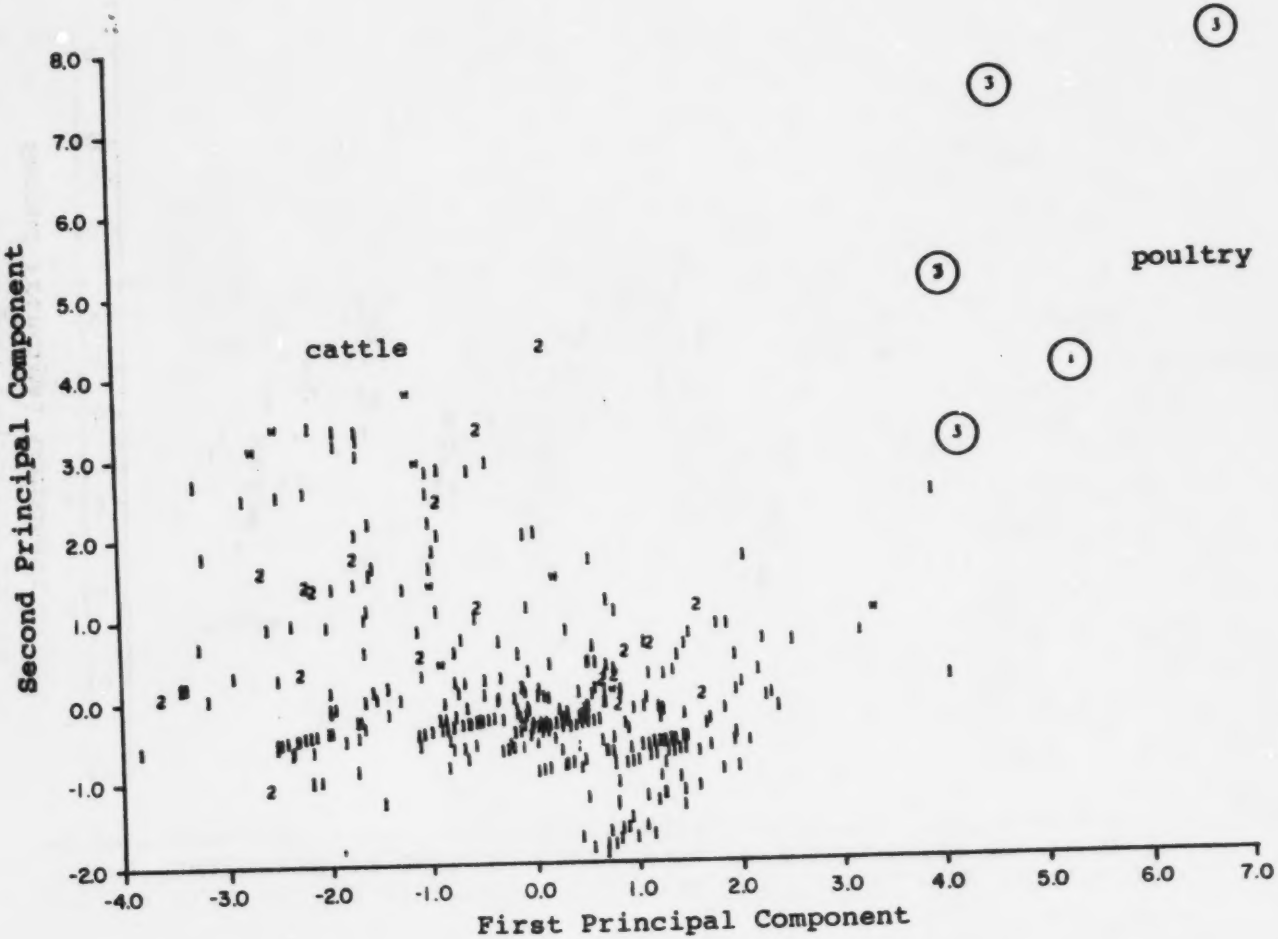


Figure 4.3

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 449 SHIPMENTS IN ALBERTA CONSISTING OF COMMODITIES IN GROUP I (LIVE ANIMALS)



In conclusion, it is apparent that careful consideration should be given, in specific instances, to the exclusion of outlying shipments and the recognition of clusters of shipments by commodity type when modelling the structure of rates.

4.3 The General Econometric Model

In order to analyze the level and structure of truck shipment rates, three stages are involved. Firstly, from economic and institutional considerations, a subset of the universe of truck shipments is defined, corresponding to a set of service characteristics. It is for this subset of shipments that an econometric model of the level and structure of rates is required and the set of characteristics might restrict attention, for example, to shipments within a given province or a group of specific commodities.

Secondly, each shipment contained in the subset under investigation provides a sequence of measurements associated with that shipment and, depending upon the requirements of the analysis, selected variables will be designated for inclusion in the model. In general, the dependent variable y will be revenue per ton-mile for the shipment concerned and will be included in the model in the logarithmic form $Y=\ln y$. The independent variables x_j will in general consist of items such as shipment weight and distance, the populations of the origin and destination of the shipment, the month, and the estimated long-run average cost. In addition, they will also include a limited number of indicators or dummy variables as required. The independent variables will also be included in the model in logarithmic form $X_j = \ln x_j$.

The third step is to specify a model whereby Y may be approximated by a linear combination of the independent variables X_j and to estimate coefficients b_j so that

$$Y = \sum_{j=1}^{P} b_j X_j$$

reasonably represents the relationship for the shipments under investigation. Two distinct methodologies will be used to estimate the coefficients b_j and these are detailed in Appendix C. The first method, which may be termed Ordinary Least Squares (OLS), disregards the sample selection scheme whereby shipments were included in the TOD survey while the second method, which may be termed Weighted Least Squares (WLS), takes explicit account of the sample selection.

For each model, both methods of estimation will be adopted and a comparison made between the results. To date, investigations into the level and structure of rates from data

compiled by the TOD survey have not taken into account the sample selection scheme and an important methodological adjunct to this study will be to evaluate the effect of the sample selection scheme on the models under investigation.

Chapter 5

EMPIRICAL RESULTS

5.1 Comparison of WLS and OLS Methods

At the outset, it should be emphasized that due to differences in the assumptions contained in the OLS and the WLS methods, a comparison between the two methods is not straightforward. In particular, both methods involve the specification of an infinite super-population whose details, for brevity, have been omitted. However, a recent simulation study by Holt and Smith* concluded that for equal or near equal probability samples, the OLS and WLS methods will give similar results and either will be satisfactory. On the other hand, for unequal probability samples, OLS and WLS may give somewhat different results in which case the WLS method is preferable. Since the TOD survey did not use an equal probability sample design, there were some a priori expectations that differences would exist between OLS and WLS in favour of the WLS method.

In this study both the OLS and WLS methods were adopted for comparison purposes and in order to assess the importance of the sample design. The results of the two methods are compared for a total of 42 regression models (see Table 5.1) developed in this study based on the following three criterions: (a) the percentage of explained variation (R^2), (b) the stability of the regression coefficients as represented by the t values of the coefficients and, (c) the biases of the Ordinary Least Squares estimators.

First, Table 5.1 presents a comparison of the performance of the OLS and the WLS methods based on the R^2. The equations with higher R^2 values are considered to be performing better. The following two points are derived from Table 5.1:

(a) Overall, in about 52% of the cases, the Weighted Least Squares method performs better on the TOD data in terms of the R^2 measure while in about 26% of the cases, the Ordinary Least Squares method fits better. The remaining 22% of the cases show that the percentages of variations explained by the WLS models and the OLS models are similar.

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* D. Holt and T. Smith, Regression Analysis of Data from Complex Surveys,(1979) p. 31.

Table 5.1

A COMPARISON OF THE PERFORMANCE OF THE OLS AND THE WLS METHODS BASED ON THE VALUE OF R^2

	Number of Equations			
	WLS Performs Better	OLS Performs Better	No* Difference	Total No. of Equations
Equations for value-of-service-pricing analysis	8	5	5	18
Equations for analysis of TL/LTL by commodity groups and by provinces	9	5	4	18
Equations for analysis of TL/LTL totals by provinces	5	1	0	6
Total	22	11	9	42

* No difference means that the difference in the value of R^2 between the two methods is less than 1%.

(b) The OLS method seems to be better in cases where data is disaggregated into homogeneous groups as opposed to cases where data is more aggregated. For instance, in the value-of-service pricing analysis where data used is at the three-digit SCC level, only 8 out of the 18 equations developed show better results with the WLS method, while 5 show better results with the OLS method and the remaining equations show little difference in R^2 between the two methods. However, in modelling TL and LTL totals, the Weighted Least Squares method is superior to the Ordinary Least Squares method.

Second, the comparison of the stability of regression coefficients between the two methods is more complicated because the rate models are based on the multiple regression analysis. For example, in the same equation, using WLS, some coefficients may be more stable while others less stable than the corresponding coefficients derived from OLS. However, generally speaking, the t values of the regression coefficients in the WLS equations are lower than the t values in OLS equations; in other words, the WLS estimators tend to have higher standard errors. Nevertheless, most of the significant variables in OLS, such as weight and distance etc., remain significant in WLS models. Furthermore, with few exceptions, the signs of the coefficients in OLS models are generally consistent with those in WLS models.

Finally, one of the main concerns over the methodology is the possible biases in the Ordinary Least Squares estimators when samples are obtained from a complex survey. However, unlike the simulation study mentioned earlier in this section, the real values of the parameters (betas) in this study are unknown. Therefore, the relative biases of the two methods cannot be compared. The population structure has a great effect on the performance of the OLS method and the results illustrate that OLS may be satisfactory in some circumstances but not in others. Evaluation of the conditional biases of the regression estimators under different population structures is an area in need of both theoretical and empirical research. However, this is beyond the scope of this study.

5.1.1 Conclusion

Overall, the WLS method seems to be a viable alternative to the OLS method for use on data from complex sample design. The WLS method is not as widely used as the OLS, therefore, more theoretical and empirical research work is required to support it. However, considering the facts that data from the For-Hire Trucking Survey have been selected from different strata and that the WLS method fits better than the OLS method in the majority of the TOD data groups studied, the results of the WLS method will be used for the following empirical analyses in this study.

5.2 Value-of-Service Pricing

Theoretically, value-of-service pricing can be interpreted as prices varying inversely with the elasticity of demand for transportation services. The elasticity of demand for transportation can be written as follows*:

$$E_{tran} = \frac{F}{P + F} \left[\frac{Es\ Ed}{Es - (1 - \frac{F}{P + F})\ Ed} \right]$$

where F = Freight rate per unit quantity of the commodity
P = Unit value of the commodity
Es = Elasticity of supply of the commodity
Ed = Elasticity of demand for the commodity

If the limit of E_{tran} is taken as the elasticity of the supply approaching infinity, then

$$E_{tran} = \frac{F}{P + F} \cdot Ed$$

Thus, the elasticity of demand for transportation is a function of the elasticity of demand for the commodity. Also it is inversely related to the value of the commodity, in that, if the value of the commodity increases, the elasticity of demand for transportation decreases. Besides, the formula indicates that the lower the freight incidence (the percentage of transportation cost in the final price of the commodity), the lower the elasticity of demand for transportation.

It is, therefore, not surprising that the value of the commodity is used as a rough indicator of the elasticity of demand for transportation by carriers of various transportation modes, for instance, in liner shipping.** However, value-of-service pricing can only exist in a market where competition is imperfect. Therefore, questions often arise as to whether economic regulations which interfere with free competition have significant impact on carriers' rate systems.

In order to determine whether entry and rate regulations have prompted the motor carriers to adopt the value-of-service pricing policy, an econometric analysis is applied on the shipments of seven pairs of commodities in Québec, Ontario and Alberta. The commodities are selected based on Table 4.3 which shows the most frequently occurring commodities at the

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* A derivation of the formula can be found in Bennathan and Walters, The Economics of Ocean Freight Rates, (1969), pp. 109-115.

** Bennathan and Walters (1969), op. cit. p. 21.

three-digit SCC code level. The commodities are paired on the basis that they incur similar transportation costs but are different in value, with one commodity relatively more valuable than the other. To reflect similar transportation characteristics and costs, each pair of commodities is selected from one SCC commodity group. The major difficulty encountered in the selection process is that some commodities which are considered suitable for value-of-service pricing analysis do not have enough observations in some provinces. Therefore, choice is first limited to those commodities which are common and with a large number of observations in all three provinces. However, in order to obtain more cases, three pairs of commodities, in which comparison can only be made between two provinces are also included in the analysis. Specifically, because of the lack of data, the rate analysis of two commodity pairs (hogs/cattle and gasoline/fuel oil) are excluded for Québec, and the meat/vegetable commodity pair is excluded from the rate analysis for Ontario. Table 5.2 presents the commodity pairs selected.

Based on the assumption that rates vary according to the value of commodity rather than transportation costs, a regression equation of the following functional form is fitted for each pair of commodities selected in the three provinces:

$$\text{Ln } R = B_1 \text{ Ln } W + B_2 \text{ Ln } H + B_3 V + U$$

where
- R = Revenue per ton-mile
- W = Weight of shipment in tons
- H = Length of haul
- V = Value indicator, with the high-value commodity designated as 1 and the low-value commodities as 0
- U = A disturbance term

The empirical results of the coefficients on the value variables are summarized in Table 5.3 and the detailed outputs of a total of 18 equations developed for value-of-service analysis are included in Tables 5.4 through 5.10. The results shown in Table 5.3 are interpreted below:

(a) In the first pair, represented by cattle and hogs, the relationship between rate and value of commodity is not significant in both Ontario and Alberta. In other words, rate is not differentiated by the type of Live Animals shipped in both regulated and unregulated provinces.

(b) A substantial rate differential between meat and vegetable shipments is found in Québec; the positive, significant and sizable coefficient in Québec indicates that the rate for shipping meat is much higher than for shipping vegetables. However, this coefficient is not statistically significant in Alberta.

Table 5.2

COMMODITY PAIRS SELECTED FOR VALUE-OF-SERVICE PRICING ANALYSIS

Commodity Pairs	SCC Codes	Commodity Groups	Provinces
(1) Cattle*/Hogs	001/003	I	Alberta, Ontario
(2) Meat*/Vegetables	011/091	II	Alberta, Québec
(3) Cereal Grain, Unmilled/Bakery*	061/064	II	Alberta, Ontario, Québec
(4) Sand, Gravel & Stone/ Other Crude Non-Metallic Minerals*	276/279	III	Alberta, Ontario, Québec
(5) Gasoline*/Fuel Oil	431/432	IV	Alberta, Ontario
(6) Other Chemicals - Industrial*/ Petroleum and Coal Products	429/439	IV	Alberta, Ontario, Québec
(7) Motor Vehicle Equipment*/Other End Products	588/945	V	Alberta, Ontario, Québec

* Denotes the high value commodity.

Table 5.3

COEFFICIENTS ON THE VALUE VARIABLES

		Québec	Ontario	Alberta
(1)	Cattle/Hogs	N/A	.1193	.272
(2)	Meat/Vegetables	2.364*	N/A	-.0223
(3)	Cereal Grain/Bakery	2.604*	1.8901*	.7664*
(4)	Sand, Stone/Other Non-Metallic Minerals	0.1324	.5832*	.3239*
(5)	Gasoline/Fuel	N/A	.0516	.0724*
(6)	Other Chemical-Industrial/Petro-Product	.3565*	.7382*	-.6346
(7)	Auto Equipments/Other End Products	-.4874*	.6044*	-.4421

Notes:

* Signifies a t ratio greater than 2.0 in absolute value.

N/A Means regression analysis was not performed due to lack of observations.

(c) For bakery and cereal grain (unmilled), all three provinces show positive significant coefficients on value variables, implying that rates for moving high-value bakery are higher than rates for moving low-value unmilled cereal grain on a per ton-mile basis. The rate differential is largest in Québec, and smallest in Alberta. It is worth noting that the three regression equations all have high R^2 values (0.81, 0.92 and 0.90) indicating that for this group of commodities, the relationships depicted by the rate models are sound.

(d) In Ontario and Alberta, the rates for shipping low-value sand, gravel and crude stone are found to be lower than rates for shipping the relatively high-value other non-metallic minerals. The rate differential is greater in Ontario than in Alberta. However, the fitting of the Ontario rate model is not very good in terms of percentage of the explained variation. In Québec, the coefficient on the value variable is not statistically significant.

(e) For the gasoline/fuel oil commodity pair, no conclusion can be drawn because the equations are poorly fitted in both Alberta and Ontario (Québec was excluded from the analysis because of lack of data on gasoline). However, taking the results at face value, the coefficient on the value variable is positive and significant in Alberta and positive but not significant in Ontario.

(f) The rate differentials between other chemical-industrial and petroleum and coal products are found positive and significant in both Ontario and Québec but negative and insignificant in Alberta.

(g) For the group of auto equipment and other end products, a significant and positive relation between rates and value of commodity is found in Ontario. The relation is significant but negative in Québec, and negative but insignificant in Alberta. It is not immediately clear whether the unit value of other end products is higher than the unit value of auto parts and accessories in Alberta and Québec. If so, then the theory of the value-of-service pricing can still be applied to Québec and Alberta. Overall, the analysis indicates that there are significant rate differentials between these two commodities in Ontario and Québec but not in Alberta.

5.2.1 Conclusion

In summary, the value of commodities seems to have some effect on rates in all commodity groups except Live Animals. The effect seems to be more important in the groups of Food Products, Minerals and Fabricated Materials as indicated by the analysis of selected commodities. In these cases, higher rates go with high value commodities. It is interesting but not

surprising to find that in most cases, the value effect of commodities in rates is more significant in Québec and Ontario than in Alberta. Although limited by data, the comparison between Ontario and Québec can only be performed based on four pairs of commodities; it is found that in three out of the four cases, Ontario shows more sizable coefficients than Québec. It is consistent with the hypothesis that entry control without strong rate regulation will enable the trucking firms to adopt a more flexible pricing policy. Overall, the results seem to suggest that entry and/or rate regulations do have some impact on the value-of-service pricing. This conclusion, however, is based on two assumptions; 1) the traffic mix by the three digit SCC code is homogeneous across the provinces and 2) the cost differentials between shipping the paired commodities in the three provinces are similar.

Table 5.4

CATTLE/HOGS (SCC 001/003)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Ontario	-0.1315 (-3.84)	-0.3615 (-14.57)	0.1193 (0.57)	.59	225
Alberta	-0.2249 (-2.37)	-0.5159 (-12.71)	0.2720 (1.43)	.55	435

Note: Figures in brackets are t values.

Table 5.5

MEAT/VEGETABLES (SCC 011/091)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Québec	-0.0842 (-1.41)	-0.6569 (-17.15)	2.3640 (9.66)	0.64	83
Alberta	-0.4351 (-10.16)	-0.3057 (-25.32)	0.0223 (0.25)	0.72	130

Note: Figures in brackets are t values.

Table 5.6

BAKERY/CEREAL GRAINS, UNMILLED (SCC 064/061)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Québec	-0.0860 (-0.97)	-0.6570 (-4.37)	2.6040 (2.39)	0.80	58
Ontario	-0.0423 (1.70)	-0.7405 (-29.19)	1.8901 (27.32)	0.92	192
Alberta	-0.3888 (-28.93)	-0.4232 (-38.11)	0.7664 (9.23)	0.90	853

Note: Figures in brackets are t values.

Table 5.7

SAND, GRAVEL, CRUDE STONE/OTHER METALLIC MINERALS (SCC 276/279)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Québec	-0.3765 (-3.14)	-0.3377 (-6.84)	0.1324 (0.66)	0.57	214
Ontario	-0.0527 (1.92)	-0.9012 (-29.85)	0.5832 (3.84)	0.46	601
Alberta	-0.0995 (-2.08)	-0.6219 (-12.29)	0.3239 (2.55)	0.55	1 080

Note: Figures in brackets are t values.

Table 5.8

GASOLINE/FUEL OIL (SCC 431/432)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Ontario	-0.4501 (-3.97)	-0.2393 (-3.60)	0.0516 (0.19)	0.36	91
Alberta	-0.3828 (12.59)	-0.3940 (-17.19)	0.0724 (2.04)	0.42	1 030

Note: Figures in brackets are t values.

Table 5.9

OTHER CHEMICALS/PETROLEUM & COAL PRODUCTS (SCC 429/439)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Québec	-0.4245 (-19.99)	-0.2689 (-18.36)	0.3565 (4.61)	0.82	278
Ontario	-0.3450 (-5.02)	-0.3970 (-6.86)	0.7382 (-8.13)	0.49	952
Alberta	-0.5748 (-12.01)	-0.2046 (-6.02)	-0.6346 (-1.95)	0.82	183

Note: Figures in brackets are t values.

Table 5.10

AUTO EQUIPMENT/OTHER END PRODUCTS (SCC 588/945)

REGRESSIONS FOR THE VALUE-OF-SERVICE PRICING ANALYSIS

Provinces	Independent Variables			$\bar{R}^2$	Number of Observations
	W	D	V		
Québec	-0.5571 (-20.37)	-0.2009 (-10.36)	0.4874 (-3.03)	0.86	340
Ontario	-0.5029 (-17.49)	-0.2872 (-10.15)	0.6044 (4.10)	0.67	71
Alberta	-0.6586 (-11.60)	-0.2942 (-8.12)	-0.4421 (-1.77)	0.87	98

Note: Figures in brackets are t values.

5.3 Rate Level and Structure Analysis

5.3.1 Model Specification

The rate structure models to be used for empirical analysis of the impact of economic regulations on the level and structure of trucking rates are of the following functional forms:

$$\text{Ln } R = B_1 \text{ Ln } C + B_2 \text{ Ln } W + B_3 \text{ Ln } D + B_4 \text{ Ln POPO} + B_5 \text{ Ln POPD} + B_6 M + B_7 \text{ INEX} + U$$

Where
- R = revenue per ton-miles of the shipment
- C = carriers' estimated long-term average cost (adjusted)*
- W = shipment weight in tons
- D = length of haul
- POPO = population of the origin of the shipment
- POPD = population of the destination of the shipment
- M = month of the shipment
- INEX = Indicator of intra (I = 0) and inter (I = 1) provincial shipments
- U = A disturbance term

The above model is specified in order to be able to simultaneously and consistently study the following four areas:

(a) Rate level comparisons between the unregulated province of Alberta and the regulated provinces of Québec and Ontario;

(b) Rate differentials between intra and interprovincial shipments;

(c) Cross-subsidization between large and small shipments; and

(d) The small community issue.

Each of the seven independent variables is assumed to have a major impact on the variation of trucking rates. Of these, evidence from existing studies indicates that the weight and distance variables are the most significant explanatory variables for rates.

The variables of the populations of the origin and the destination of the shipment are built in the model to assess the rate differentials between large and small communities. Details of the development of population variables are included in Appendix A.

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* The costs were calculated from translog cost functions where the explanatory variables were the levels of carriers' output and the prices of input factors.

The indicator of intra and interprovincial shipments is a dummy variable used for evaluating rate differentials between the two groups of shipments.

The cost variable which represents the carrier's estimated long-run average cost per ton-mile is derived based on the earlier Canadian Transport Commission study on the cost structure of Canadian For-Hire Trucking.* Although the average costs do not reflect the costs of individual shipments, they are used in the model to account for individual carrier differences. However, an adjustment has to be made to the cost estimates before applying them to the rate study, because the cost structure models were derived based on the Motor Carriers-Freight and Household Goods Movers (MCF)** survey and represented total operating expenses while the rates (revenue per ton-mile) are based on the TOD survey and represent only freight transportation revenues of the shipments. Two steps are taken to make the adjustments. First, a cost adjustment factor is developed for each carrier by taking the ratio of estimated total freight transportation revenue from the TOD survey over total operating revenue of the carrier reported in the MCF survey; second, the carrier's estimated long-run average cost is multiplied by the adjustment factor to obtain the adjusted costs.

Finally, the purpose of including the month variable in the model is to take into account the rate increases during the year.

The rate models are fitted separately for TL and LTL shipments because the two types of traffic have different operating characteristics and cost structures. Furthermore, three commodity groups, namely, Food and Beverages, Fabricated Materials and End Products (SCC groups II, IV and V) are selected for more detailed studies. The other three SCC commodity groups (I, III and VI) are excluded from further analysis either because of low overlap or high predominance of some commodities between the provinces. Overall, a total of 24 separate rate structure models are developed, i.e., two traffic segments (TL, LTL) by four groupings (three commodity groups plus totals) and by three provinces ($2 \times 4 \times 3 = 24$).

The results of the Weighted Least Squares models are used for empirical analyses. The detailed outputs of the 24 regression models are presented in the following Tables 5.11 through 5.18. Detailed analyses are presented in the following subsections.

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* M.B. Cairns and B.D. Kirk op. cit.

** Statistics Canada, Motor Carriers - Freight and Household Goods Movers, 1961.

Table 5.11

LTL TOTAL
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							$\bar{R}^2$	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	-0.044 (-1.85)	-0.527 (-41.88)	-0.545 (-37.62)	0.059 (11.17)	0.049 (8.11)	0.017 (3.54)	-0.204 (-4.05)	0.73	3 494
Ontario	0.760 (18.25)	-0.271 (- 8.53)	-0.547 (-22.41)	0.102 (10.30)	0.073 (9.66)	0.061 (9.32)	0.063 (0.44)	0.79	2 218
Alberta	-0.256 (-4.93)	-0.562 (-31.33)	-0.462 (-14.24)	0.024 (3.26)	0.004 (0.52)	0.005 (1.28)	0.130 (1.91)	0.81	1 941

Note: Figures in brackets are t values.

Table 5.12

LTL GROUP II FOOD AND BEVERAGES
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							$\bar{R}^2$	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	-0.2665 (-2.31)	-0.3730 (-12.12)	-0.6815 (- 8.07)	0.1018 (3.19)	0.0139 (0.46)	0.0235 (1.58)	-0.2951 (-2.21)	0.58	370
Ontario	-0.0366 (-0.53)	-0.1636 (- 3.58)	-0.6785 (-26.64)	0.0788 (12.22)	0.0208 (2.54)	0.0062 (1.00)	—0.0167 (-0.10)	0.69	813
Alberta	-0.1228 (1.29)	-0.4649 (-14.41)	-0.2991 (- 4.30)	-0.0043 (-0.23)	0.0170 (1.10)	0.0005 (0.06)	-0.7574 (-4.76)	0.77	285

Note: Figures in brackets are t values.

Table 5.13

LTL GROUP IV FABRICATED MATERIALS
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							$\bar{R}^2$	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	0.0904 (2.52)	-0.5137 (-21.25)	-0.5371 (-19.83)	0.0865 (10.09)	0.0369 (4.12)	0.0145 (1.88)	-0.1640 (-2.10)	0.76	1 070
Ontario	0.0474 (0.13)	-0.5223 (- 9.95)	-0.7763 (- 5.43)	0.1236 (6.86)	0.0825 (2.84)	0.0089 (0.58)	-0.0628 (-0.73)	0.60	345
Alberta	-0.0892 (-1.08)	-0.5519 (-22.25)	-0.4244 (- 5.64)	-0.0012 (-0.06)	-0.0570 (2.89)	-0.0066 (-0.73)	0.2789 (1.51)	0.78	490

Note: Figures in brackets are t values.

Table 5.14

LTL GROUP V END PRODUCTS
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							$\bar{R}^2$	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	-0.1475 (-4.09)	-0.5304 (-26.10)	-0.5372 (-32.01)	0.0431 (6.79)	0.0503 (7.69)	0.0170 (2.74)	0.0618 (-0.71)	0.74	1 649
Ontario	0.1468 (1.96)	-0.4747 (-11.34)	-0.5123 (- 8.94)	0.0848 (5.51)	0.0341 (2.30)	0.0488 (3.71)	-0.9766 (-0.51)	0.55	738
Alberta	-0.3595 (-3.70)	-0.5729 (-19.72)	-0.4558 (- 9.97)	0.0215 (2.41)	-0.0121 (-1.27)	0.0062 (1.24)	0.1175 (1.53)	0.84	1 080

Note: Figures in brackets are t values.

Table 5.15

TL TOTAL
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							R^{-2}	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	0.343 (9.35)	-0.330 (- 9.94)	-0.427 (-16.67)	0.038 (7.88)	0.063 (12.65)	0.024 (6.05)	0.162 (3.70)	0.51	3 476
Ontario	0.820 (30.79)	-0.140 (- 7.31)	-0.244 (-18.43)	0.043 (8.59)	0.037 (8.71)	0.018 (4.82)	0.031 (1.06)	0.57	5 422
Alberta	0.039 (0.98)	-0.455 (-14.75)	-0.437 (-29.63)	0.046 (12.05)	0.017 (4.21)	0.015 (5.16)	0.180 (5.04)	0.46	7 009

Note: Figures in brackets are t values.

Table 5.16

TL GROUP II FOOD & BEVERAGES
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							R^{-2}	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	0.1706 (1.43)	-0.3129 (- 1.94)	-0.4894 (- 5.46)	0.0644 (3.80)	0.0170 (1.20)	0.0393 (3.77)	0.2152 (1.16)	0.56	630
Ontario	0.4280 (6.70)	-0.2138 (- 4.04)	-0.4322 (-11.71)	0.0489 (5.64)	0.0393 (4.18)	0.0274 (3.46)	-0.1187 (-3.18)	0.58	1 237
Alberta	0.2732 (2.20)	-0.1065 (- 0.59)	-0.6017 (6.79)	0.1100 (4.52)	-0.0207 (-0.071)	0.0496 (5.28)	0.4899 (2.91)	0.48	1 170

Note: Figures in brackets are t values.

Table 5.17

TL GROUP IV FABRICATED MATERIALS
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							$\bar{R}^2$	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	0.4798 (12.39)	-0.1600 (- 4.83)	-0.4676 (-15.63)	0.0323 (6.03)	0.0660 (10.97)	0.0211 (4.04)	0.2521 (4.90)	0.54	2 085
Ontario	0.6210 (10.93)	-0.2127 (- 6.50)	-0.2798 (-13.45)	0.0340 (6.94)	0.0407 (9.06)	0.0116 (3.57)	0.0398 (0.85)	0.47	2 920
Alberta	-0.2098 (-4.09)	-0.5302 (-14.21)	-0.4358 (-25.40)	0.0149 (3.08)	0.0010 (0.23)	0.0101 (2.87)	0.1267 (3.13)	0.43	3 229

Note: Figures in brackets are t values.

Table 5.18

TL GROUP V END PRODUCTS
RATE STRUCTURE REGRESSIONS

Provinces	Independent Variables							$\bar{R}^2$	Number of Observations
	C	W	D	POPO	POPD	M	INEX		
Québec	-0.1432 (-0.82)	-0.9333 (- 9.12)	-0.2548 (- 4.45)	0.0373 (1.37)	0.0704 (3.18)	0.0186 (1.51)	-0.1301 (-1.90)	0.57	313
Ontario	0.5177 (8.74)	-0.1948 (- 2.60)	-0.2670 (- 5.23)	0.0311 (1.86)	-0.0037 (-0.27)	0.0417 (2.88)	-0.2820 (-5.67)	0.63	362
Alberta	0.5188 (5.75)	-0.4017 (- 3.42)	-0.2231 (- 5.80)	0.0618 (5.15)	0.0180 (1.67)	0.0208 (3.50)	-0.0726 (-1.19)	0.60	537

Note: Figures in brackets are t values.

5.3.2 Rate Level Analyses

A. Rate Differentials between Provinces

An argument often used against trucking regulation is that rates in regulated provinces may be higher than rates in unregulated provinces as a result of reduced competition. Based on this assumption, an à priori hypothesis is that highest rates should be in Ontario, followed by Québec, with the lowest being in Alberta. The validity of this hypothesis will be examined in this section.

In performing rate level comparisons between provinces, there is a major difference between the methodology adopted in this study and that in other studies on trucking rates. This study estimates separate rate models for different provinces, while other studies use dummy variables to represent the provinces in the same model. When provinces are represented by dummy variables, it is assumed that the relationship between revenue per ton-mile and its explanatory variables, such as weight and distance, is the same for all provinces. However, the principal component analysis performed in this study has indicated that the diversification in rate levels between provinces may be affected by the differences in provincial rate structures. For example, weight and distance may be the most important explanatory variables in both Alberta and Ontario, but the relative significance of these variables in the two provinces may differ. Therefore, a major advantage of fitting a separate model for each province is that it allows the rate structures in the provinces to vary. Furthermore, it allows comparisons of rates between provinces to be made for different weight and distance ranges.

Based on the rate structure models described in the previous section, two sets of rate curves are estimated; one depicts the relationship between revenues per ton-mile and shipment weights and the other depicts the relationship between revenues per ton-mile and distances. These estimated rate level curves by traffic segments for the three provinces are presented in 16 separate figures:

(a) Figures 5.1 to 5.4 compare between provinces, the rate levels by weights of the four LTL traffic groups, i.e., LTL Total, Food, Fabricated Materials and End Products, respectively;

(b) Figures 5.5 to 5.8 compare rate levels by distance of the LTL traffic groups;

(c) Figures 5.9 to 5.12 provide rate comparisons over the weight range of TL traffic groups; and

(d) Figures 5.13 to 5.16 provide rate comparisons over the distance range of TL traffic groups.

Figure 5.1

LTL TOTAL TRAFFIC
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

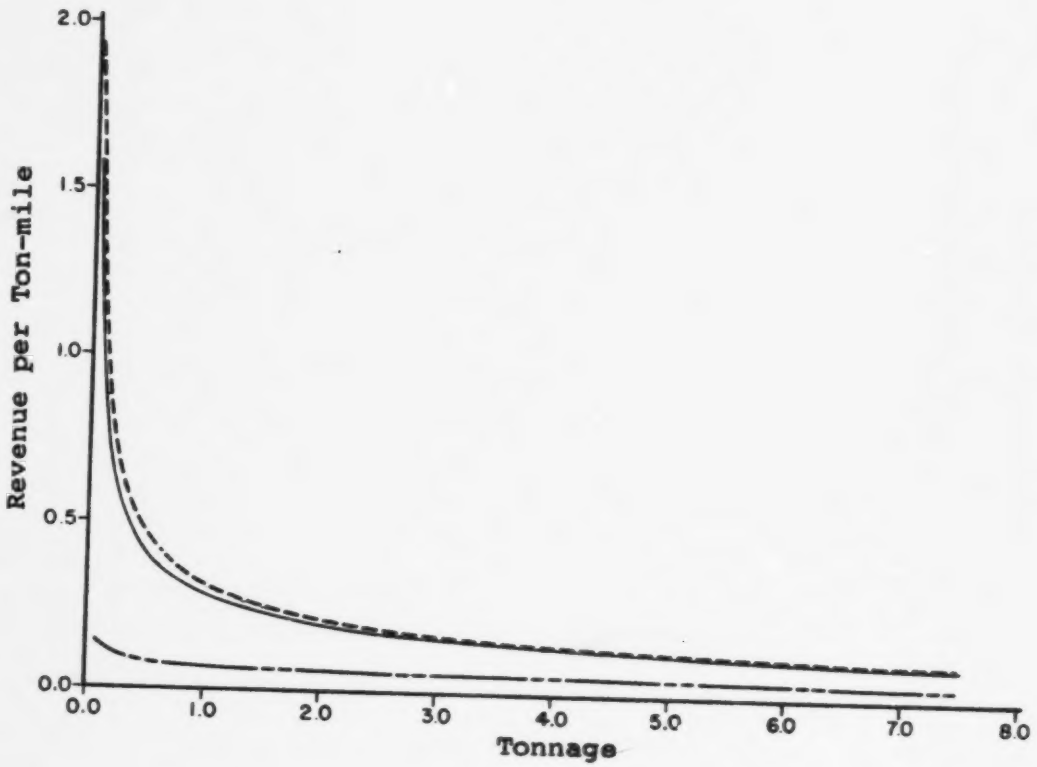


Figure 5.2

LTL FOOD & BEVERAGES
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

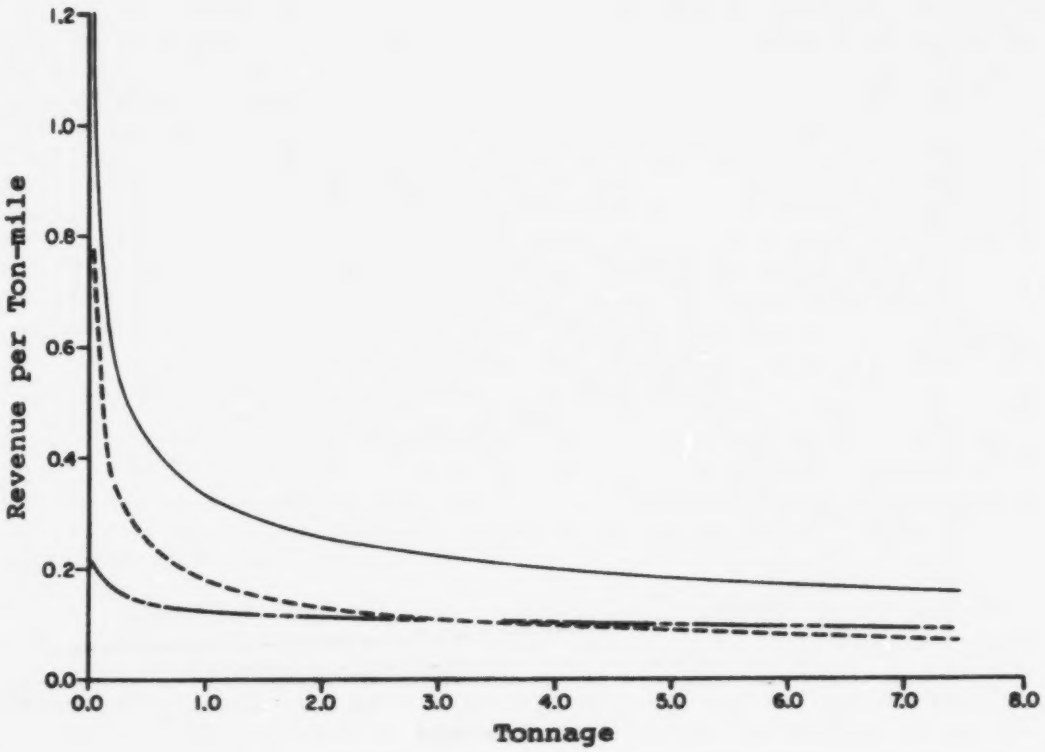


Figure 5.3

LTL FABRICATED MATERIALS
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

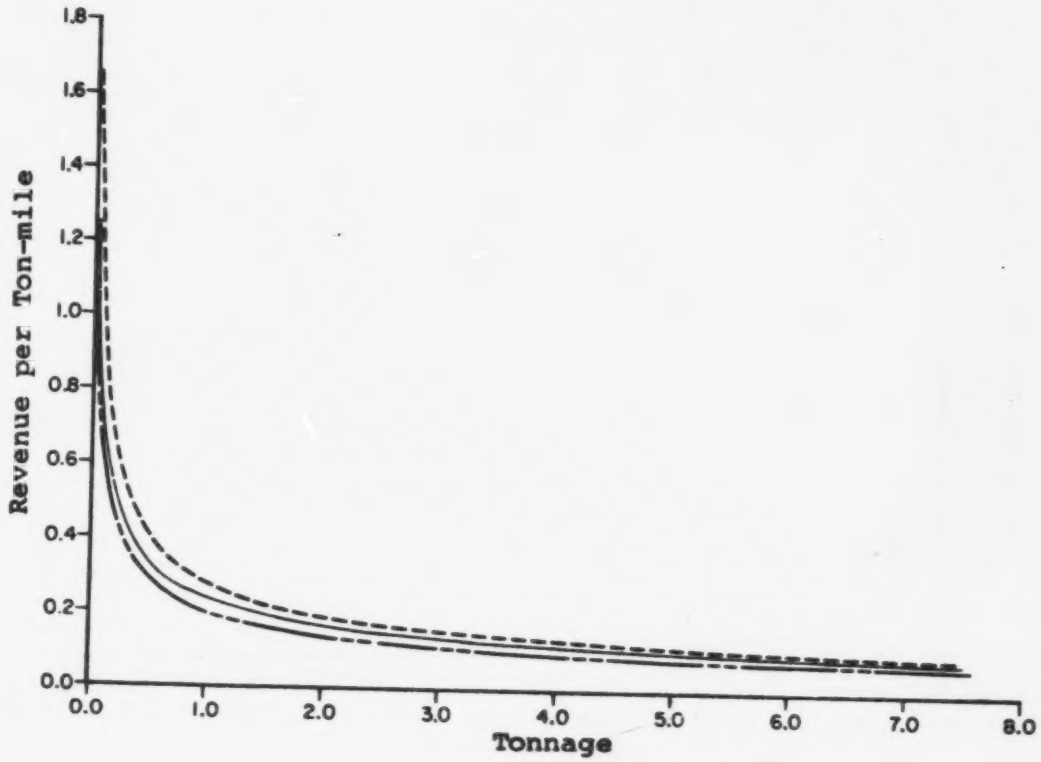


Figure 5.4

LTL END PRODUCTS
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

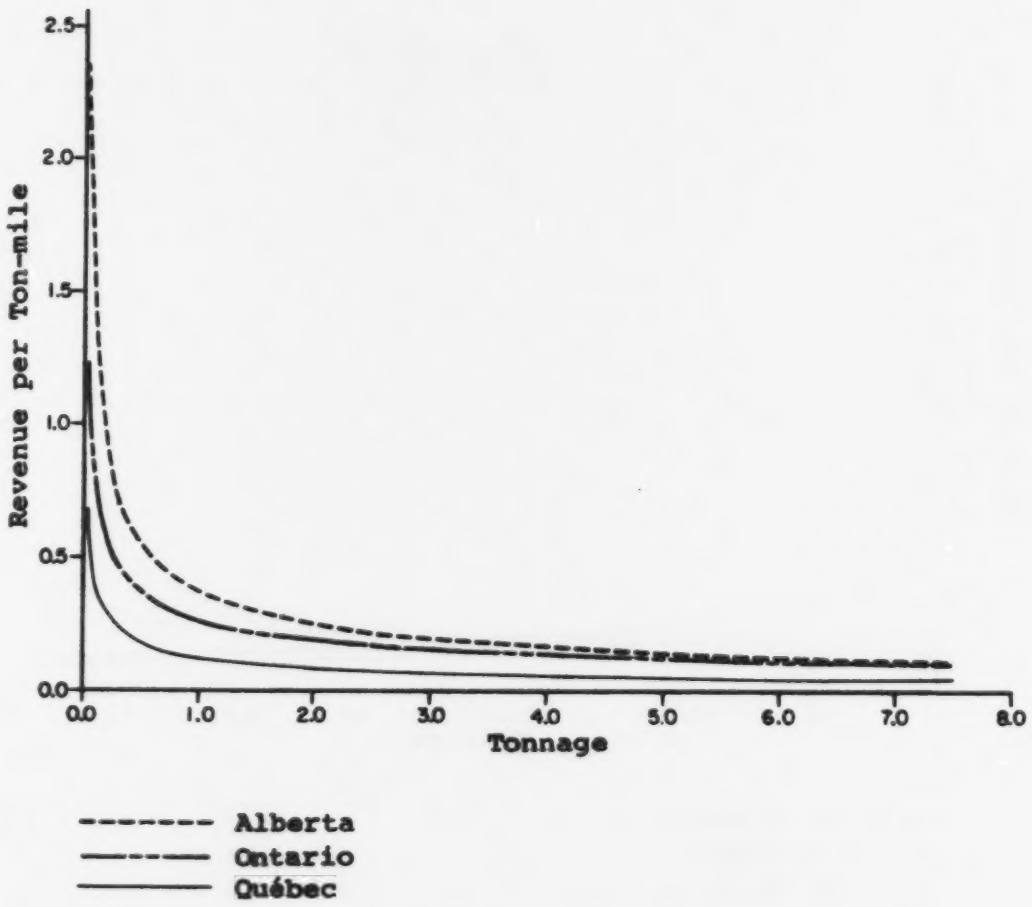


Figure 5.5

LTL TOTAL TRAFFIC
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = .73 tons

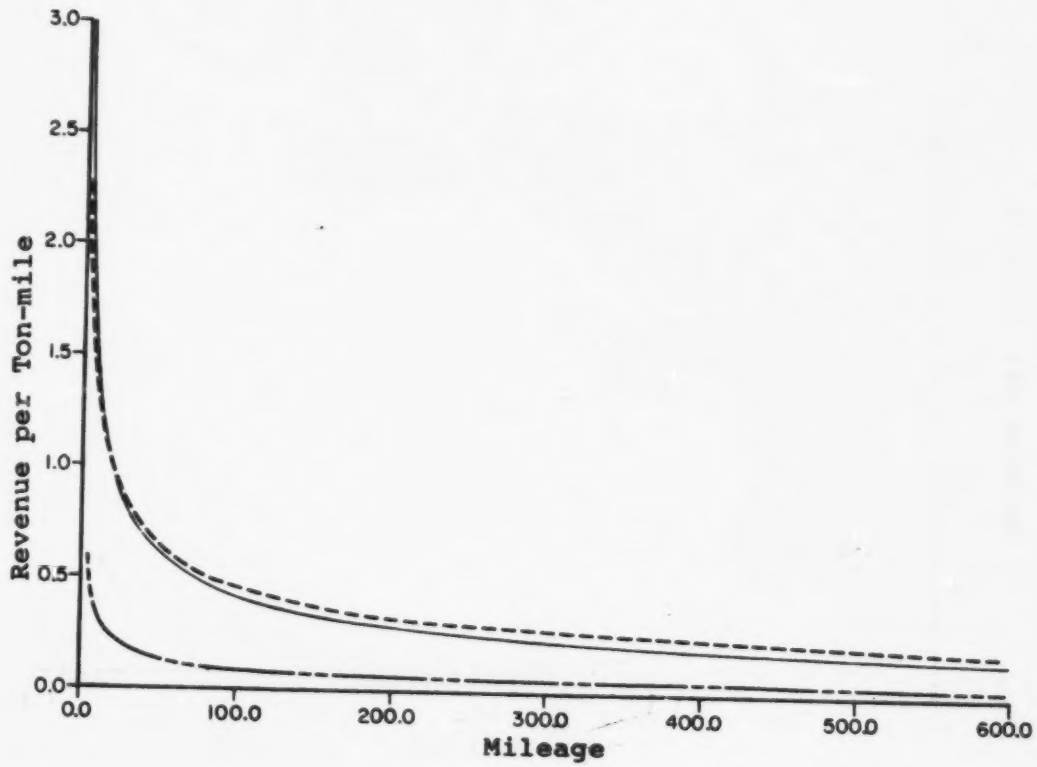


Figure 5.6

LTL FOOD & BEVERAGES
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = .73 tons

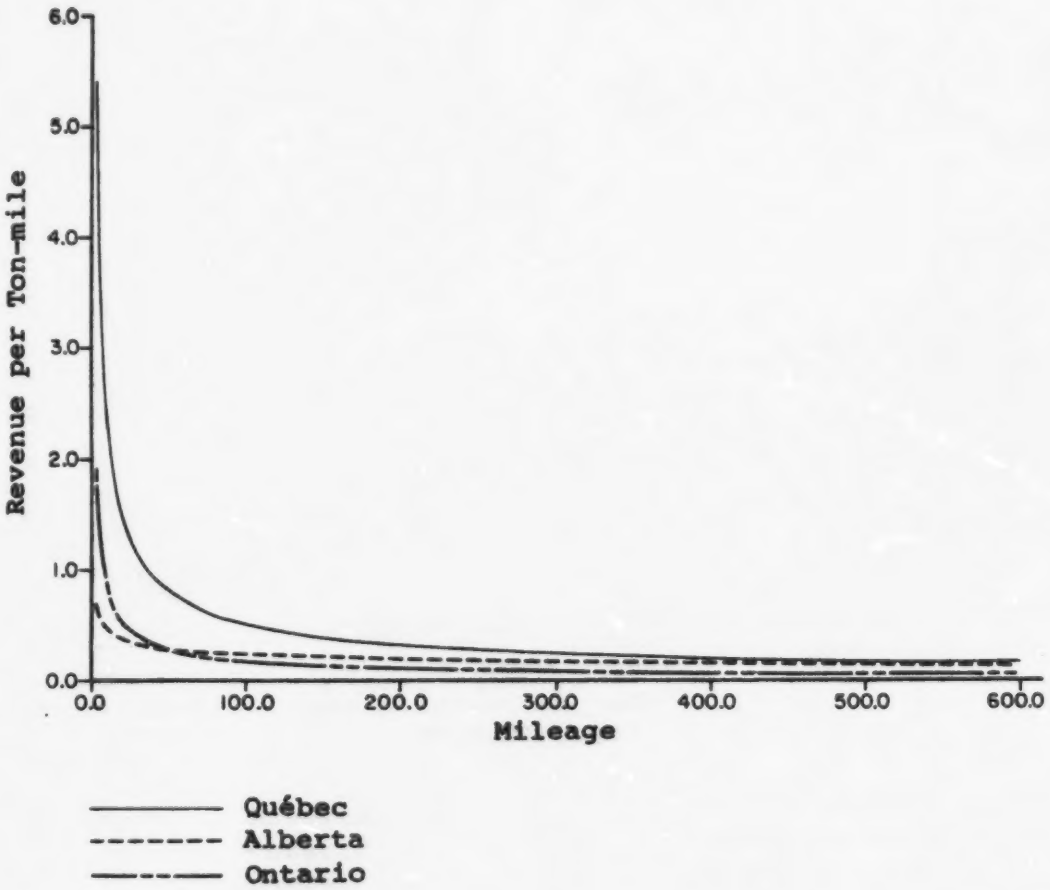


Figure 5.7

LTL FABRICATED MATERIALS
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = .73 tons

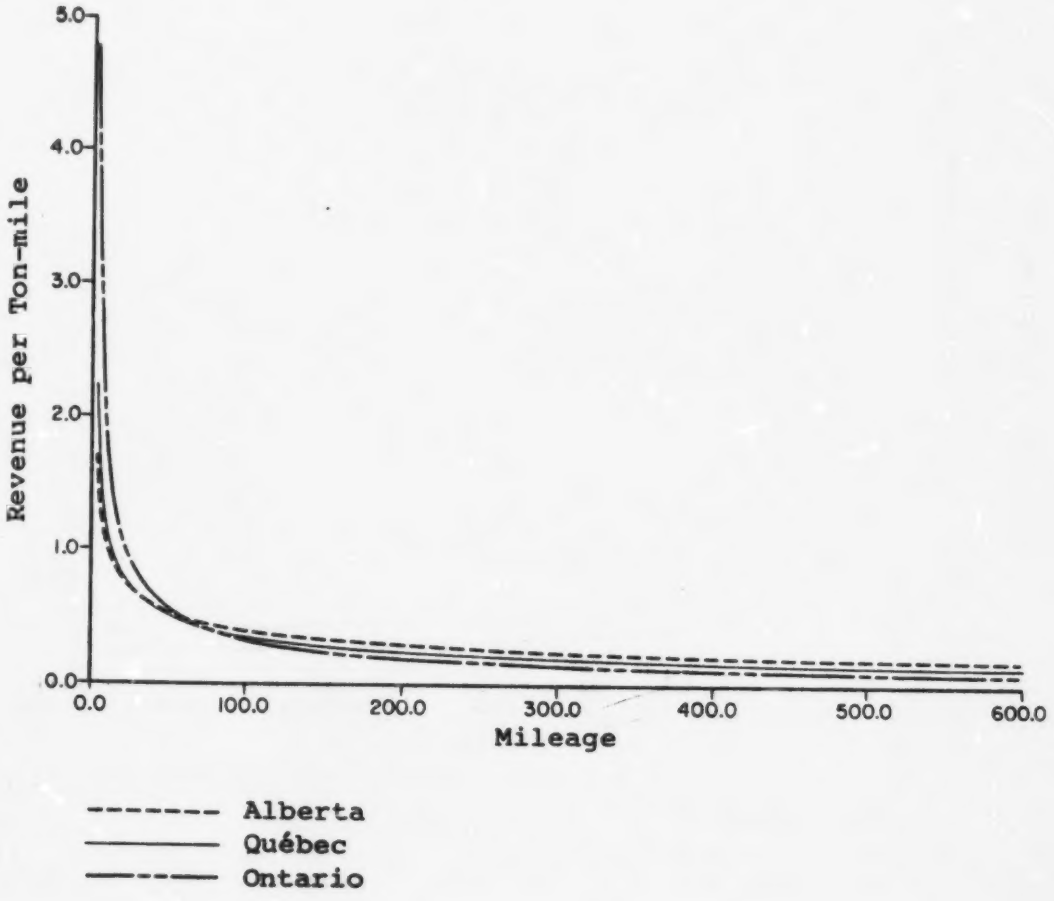


Figure 5.8

LTL END PRODUCTS
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = .73 tons

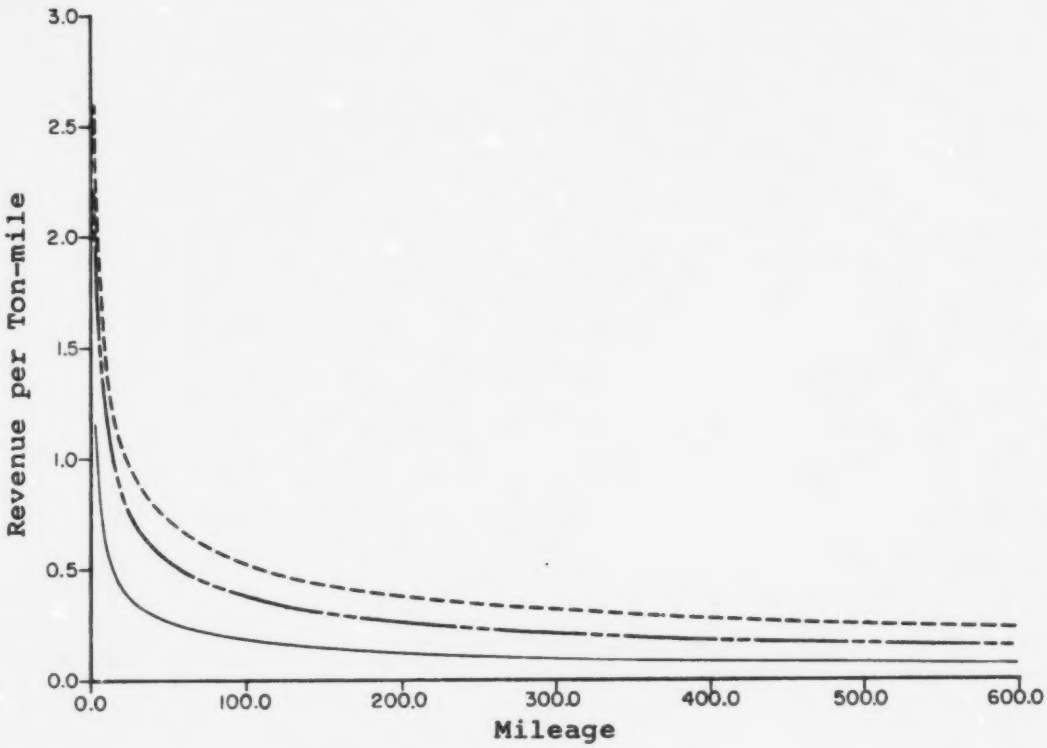


Figure 5.9

TL TOTAL TRAFFIC
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

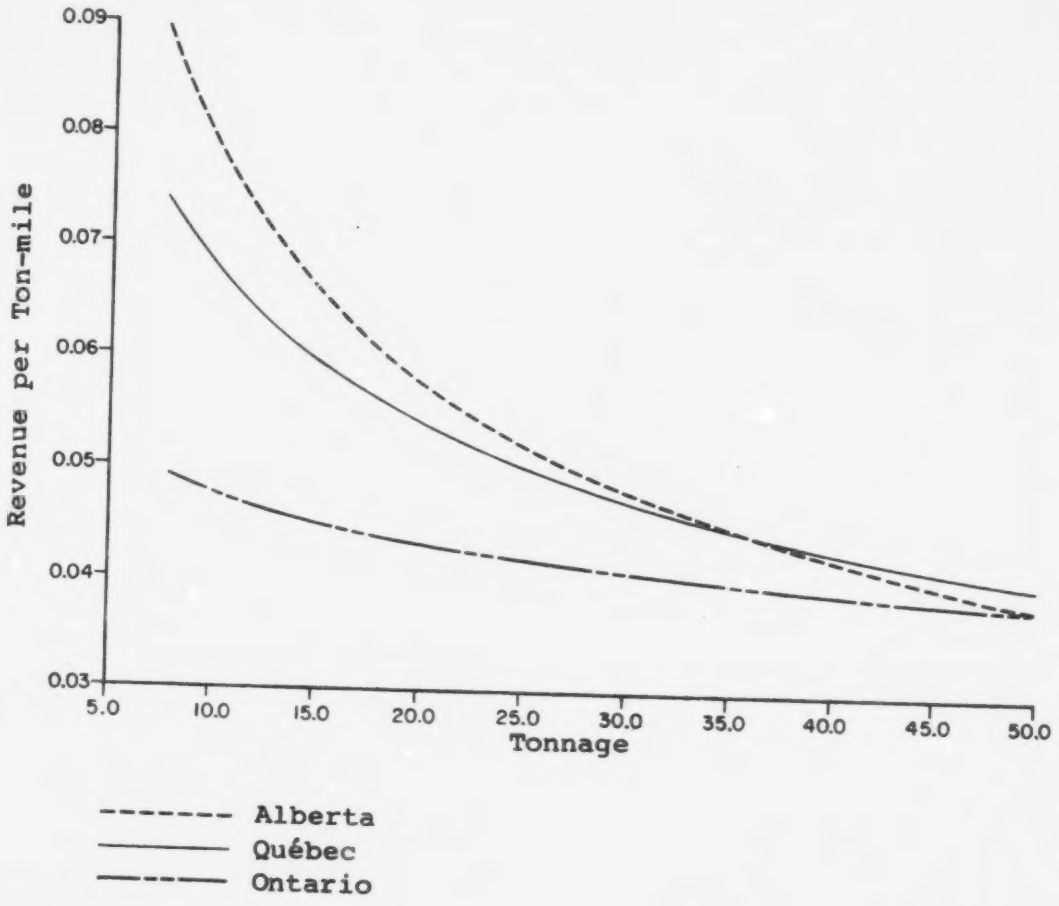


Figure 5.10

TL FOOD & BEVERAGES
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

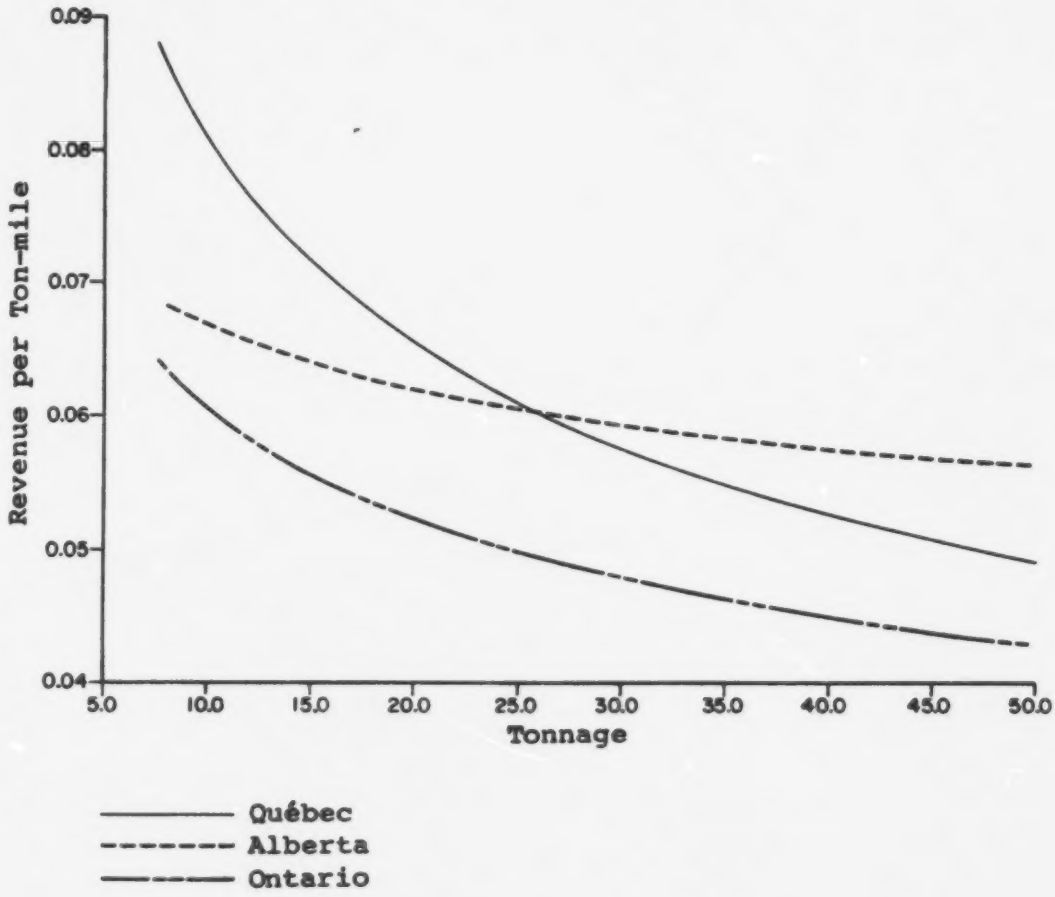


Figure 5.11

TL FABRICATED MATERIALS
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

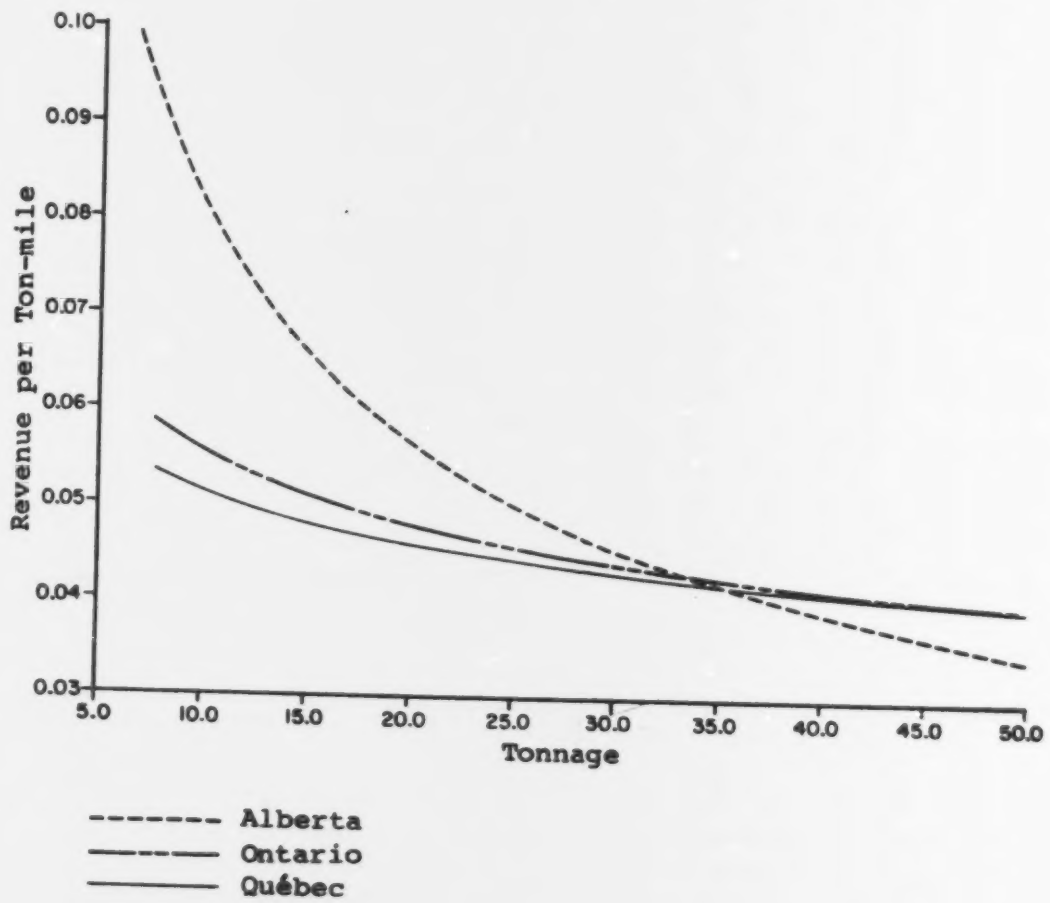


Figure 5.12

TL END PRODUCTS
ESTIMATED REVENUE PER TON-MILE BY SHIPMENT WEIGHTS

Distance = 150 miles

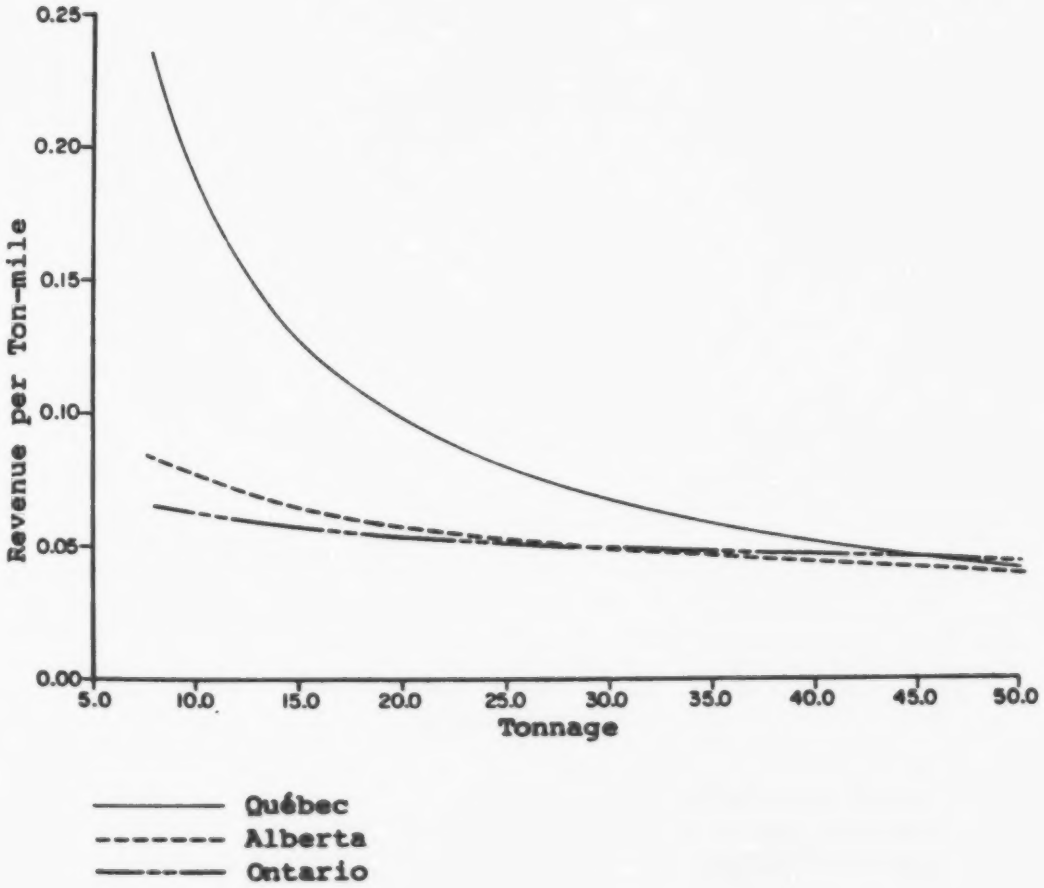


Figure 5.13

TL TOTAL TRAFFIC
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = 25 tons

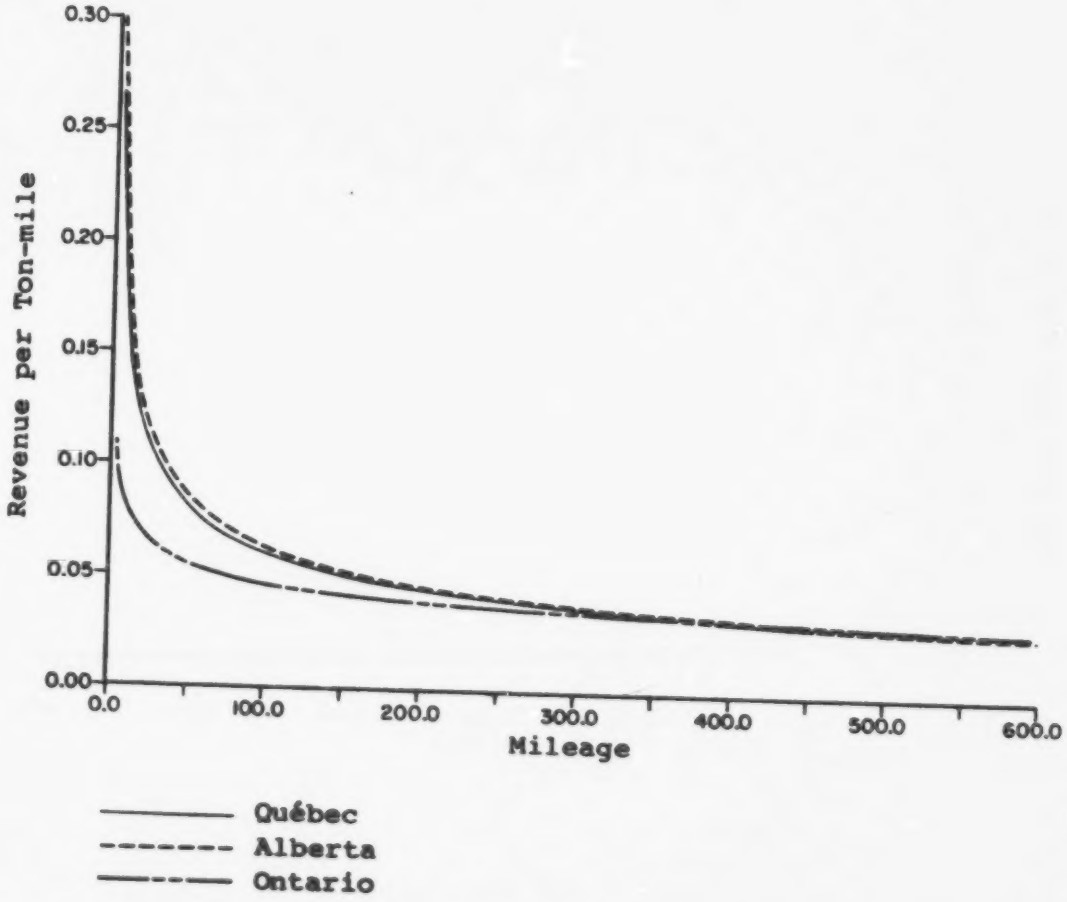


Figure 5.14

TL FOOD & BEVERAGES
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = 25 tons

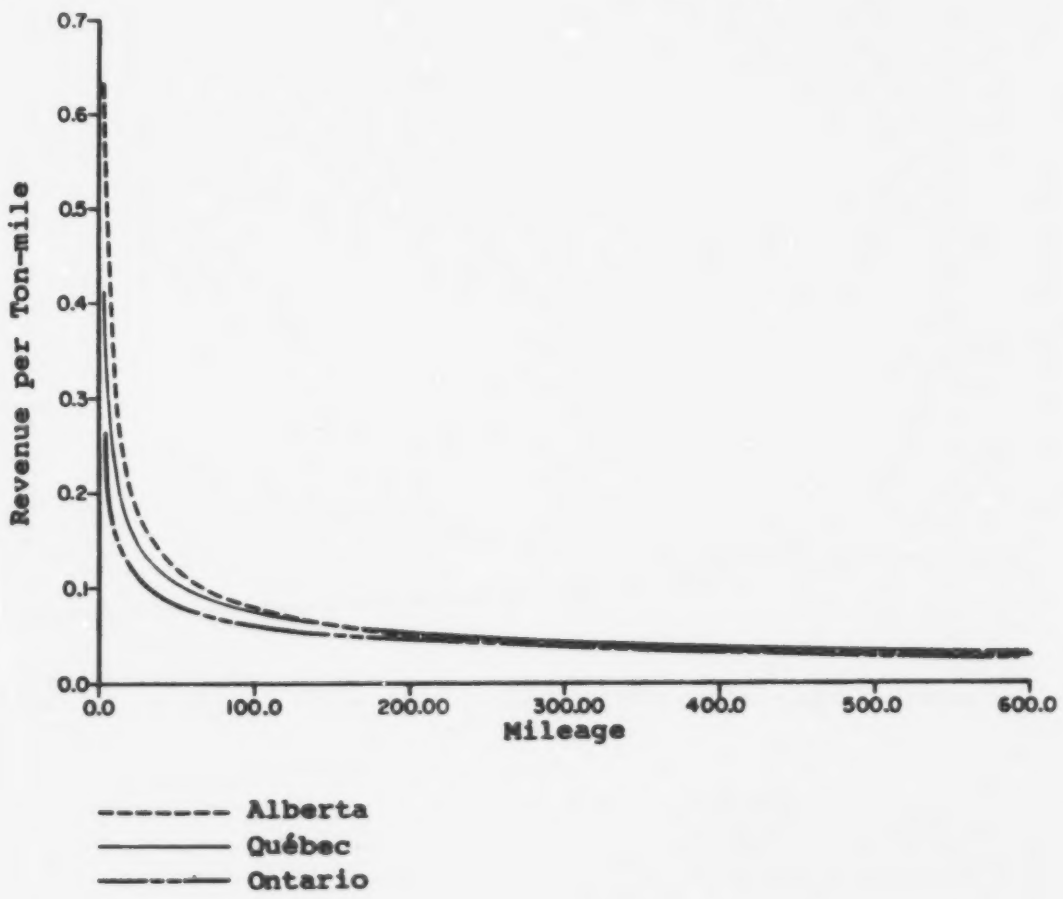


Figure 5.15

TL FABRICATED MATERIALS
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = 25 tons

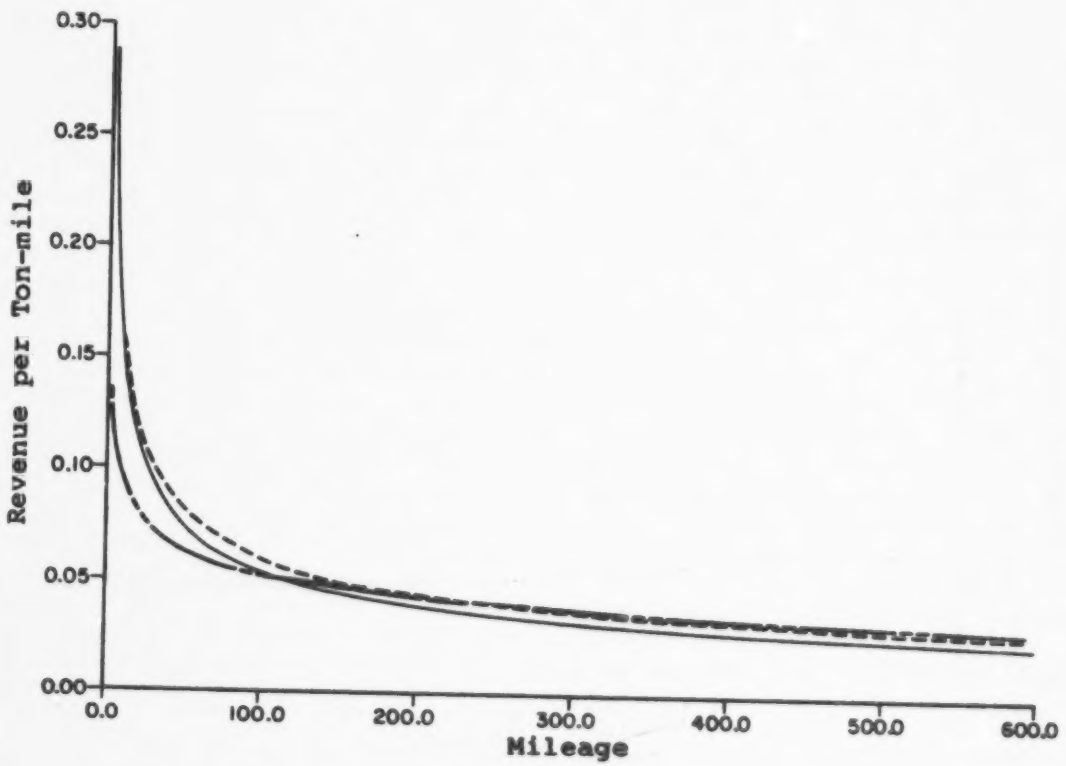
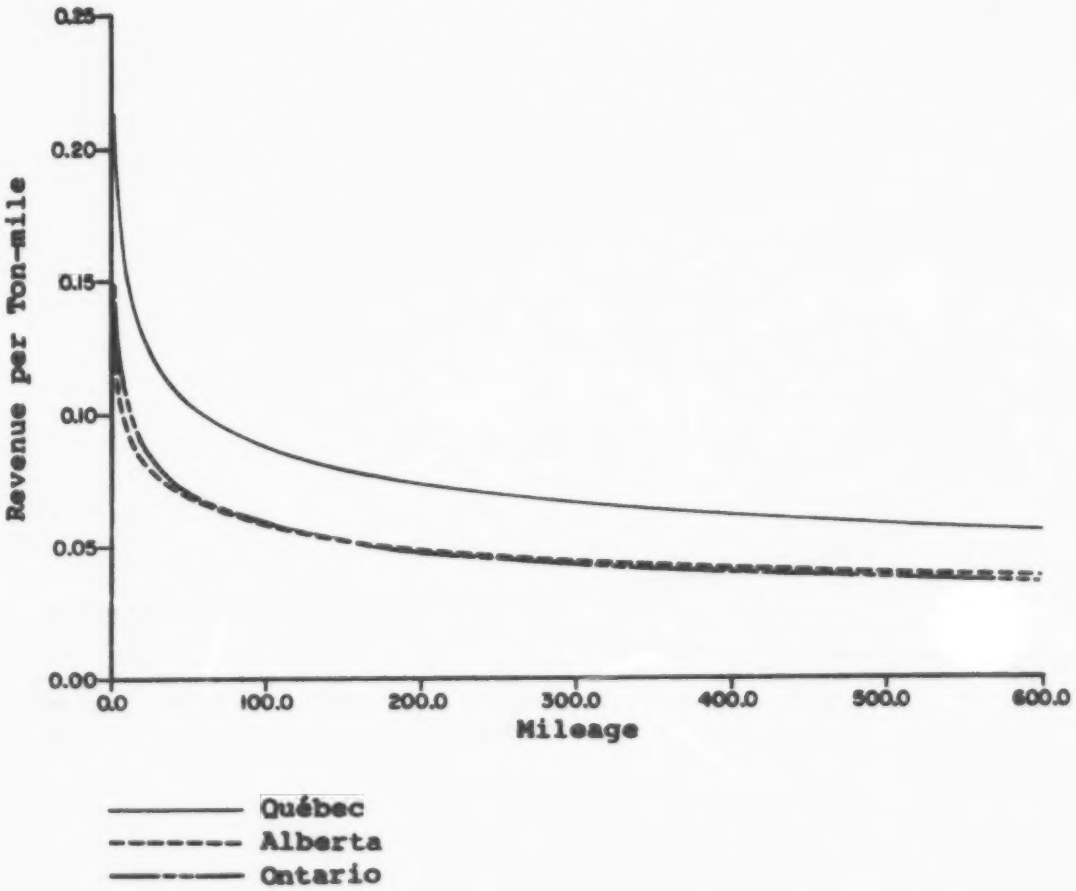


Figure 5.16

TL END PRODUCTS
ESTIMATED REVENUE PER TON-MILE BY DISTANCE

Weight = 25 tons



In the figures of rate by weight for both TL and LTL groups, all other variables except one are held fixed at their overall median values. The only exception is the variable of the inter/intra shipments indicator which is fixed to reflect the rate levels of the intraprovincial shipments only. In the figures of rate by distance, weight and all other variables are fixed in the same way as in the rate by weight figures, except for the median weights of TL and LTL traffic which are obtained separately. The median weight of TL is 25 tons and the median weight of LTL is 0.73 tons.

The weight ranges shown in Figures 5.1 to 5.4 for LTL shipments are different from those shown in Figures 5.9 to 5.12 for TL shipments. As a result, the scale of the vertical axis of these figures is quite different. These ranges are adopted to reflect the definitions of TL and LTL shipments used in this study. Later in this chapter, the fact that the rate levels of TL and LTL shipments are not really comparable is discussed. However, for those who wish to make such comparisons, attention should be focused on the rate scales rather than the appearances of the curves.

In all the figures presented, the revenues per ton-mile curves slope downward to the right. This means that the rate declines with larger shipment weights and longer distances. However, in many cases, especially in TL, the steepness of the curves is different for the three provinces, indicating that the relative rate levels of the provinces change at different weight and distance ranges. In order to get a general picture of the relative rate levels of the provinces, the results of LTL shown in Figures 5.1 to 5.8 are summarized in Table 5.19, and the results of TL shown in Figures 5.9 to 5.16 are summarized in Table 5.20. These two tables show how the provinces are ranked in terms of highest revenue per ton-mile over the different weight and distance ranges as well as across the different types of traffic.

As shown in Table 5.19, for total LTL traffic, when all other variables are held fixed at their overall median values, the rate level is highest in Alberta, followed by Québec and lowest in Ontario over the whole range of shipment weights. However, the ranks of Québec and Alberta interchange for short hauls; for shipments of median LTL weight moving less than 40 miles, the rate is highest in Québec followed by Alberta. Furthermore, referring to Figure 5.1, it is found that the rates for Alberta and Québec are fairly close especially for large shipment weights. However, consistent with the cost structure analysis of the for-hire trucking industry, the lower rates in Ontario may have resulted from relatively lower operating costs. In order to compare the relative cost and rate levels of the provinces, the rank order of the provinces in terms of highest marginal cost for different levels of output which was shown in the above-mentioned cost study is reproduced as Table 5.21. As shown in the table, the marginal cost of

Table 5.19

RANK ORDER OF THE PROVINCES IN TERMS OF THE HIGHEST AVERAGE RATE FOR LTL SHIPMENTS AT DIFFERENT RANGES OF WEIGHT AND DISTANCE

		Rank Order		
		Québec	Ontario	Alberta
1. Rate by Weight (Distance = 150 miles)				
LTL Market Segments	**Weight Ranges (Tons)**			
(a) Total	.04-7.5	2	3	1
(b) Food & Beverages	.04-3.0	1	3	2
	3.00 -7.5	1	2	3
(c) Fabricated Materials	.04 -7.5	2	3	1
(d) End Products	.04 -7.5	3	2	1
2. Rate by Distance (Weight = .73 tons)				
LTL Market Segments	**Distance Ranges (Miles)**			
(a) Total	3- 40	1	3	2
	40-600	2	3	1
(b) Food & Beverages	3- 45	1	2	3
	45-600	1	3	2
(c) Fabricated Materials	3- 40	2	1	3
	40- 60	3	1	2
	60-600	2	3	1
(d) End Products	3-600	3	2	1

Note: A rank order of 1 denotes the highest average rate (revenue per ton-mile), a rank order of 2 denotes the next highest average rate and a rank order of 3 denotes the lowest average rate.

providing LTL is highest in Alberta, second in Québec and lowest in Ontario. It is recognized that the approaches used in obtaining the cost and the rate estimates are somewhat different. First, the former is based on the MCF survey and the latter on the TOD survey; and second, the cost unit is in shipment-miles while the price unit is in ton-miles. Nevertheless, for purposes of analytical inference, the results of the cost study and the present rate study seem to be consistent.

Of the three LTL commodity groups studied, only the End Products group shows the provinces keeping consistent rank orders. In the group, the rate level of Alberta is highest, Ontario is second, and Québec is the lowest over both the weight and the distance ranges. In the Food group, rates in Québec are higher than in Alberta and Ontario; however, between Alberta and Ontario, the relative rate levels vary quite considerably over the weight and the distance ranges. Finally, in the Fabricated Materials group, Alberta shows the highest rate level over the weight range, while distance is held fixed at 150 miles, but there is no consistent rank order for Fabricated Materials over the distance range.

In the TL segment, relative rate levels of the provinces shift more frequently than in the LTL traffic groups. As shown in Table 5.20, no consistent pattern in terms of rank order of rates can be found between provinces. However, in TL total traffic, the ranking of the provinces in terms of rate levels are found consistent with their ranking in terms of costs as shown in Table 5.21.

Generally, the rate differentials between provinces in TL are less significant than in LTL. For instance, as shown in Figure 5.9 of TL total rate by weight, the rate differentials between provinces for shipments weighing more than 25 tons (which is the median weight of TL) are less than 1¢, and in Figure 5.13, TL total, rate by distance, the rate curves of the provinces overlap at a mileage range beyond approximately 350 miles, while in LTL total, as presented in Figures 5.1 and 5.5, the rate differentials between provinces are much more significant.

eConclusion

In summary, the empirical results presented above do not support the assumption that rate levels in regulated provinces are higher than rates in unregulated provinces. Although the rank orders of the provinces in terms of rates vary over different weight and distance ranges in most of the TL and LTL segments, trucking rates are found to be generally lower in Ontario than in Alberta and Québec. The results to a great extent are consistent with the findings of the cost structure analysis of the for-hire trucking industry.

Table 5.20

RANK ORDER OF THE PROVINCES IN TERMS OF THE HIGHEST AVERAGE RATE FOR TL SHIPMENTS AT DIFFERENT RANGES OF WEIGHT AND DISTANCE

		Rank Order		
		Québec	Ontario	Alberta
1. Rate by Weights (Distance = 150 miles)				
TL Segments	Weight Ranges			
(a) Total	7.5-32.5	2	3	1
	32.5-50.0	1	3	2
(b) Food & Beverages	7.5-25.0	1	3	2
	25.0-50.0	2	3	1
(c) Fabricated Materials	7.5-32.5	3	2	1
	32.5-50.0	2	1	3
(d) End Products	7.5-27.0	1	3	2
	27.0-45.0	1	2	3
	45.0-50.0	2	1	3
2. Rate by Distance (Weight = 25 tons)				
TL Market Segments	Distance Ranges			
(a) Total	3-400	2	3	1
	400-600	3	1	2*
(b) Food & Beverages	3-150	2	3	1
	150-350	1	3	2
	350-600	1	2	2*
(c) Fabricated Materials	3-125	2	3	1
	125-250	3	2	1
	250-600	3	1	2
(d) End Products	3-100	1	2	3
	100-600	1	3	2

Note: *Signifies that the differences between provinces are negligible.

Table 5.21

RANK ORDER OF THE PROVINCES IN TERMS OF THE HIGHEST MARGINAL COST AT DIFFERENT LEVELS OF OUTPUT AS DERIVED FROM THE MODELS WITH THE MEASURE OF CAPACITY UTILIZATION INCLUDED

Output	Range of Output in Shipment-Miles	Rank Order		
		Québec	Ontario	Alberta
LTL	$0.2 \times 10^6 - 4.1 \times 10^6$	2	3	1
TL Short-Haul	$0.1 \times 10^6 - 0.7 \times 10^6$	1	2	3
	$0.7 \times 10^6 - 4.3 \times 10^6$	1	3	2
	$4.3 \times 10^6 - 5.2 \times 10^6$	2	3	1
TL Long-Haul	$0.5 \times 10^5 - 14.3 \times 10^5$	1	3	2

Note: A rank order of 1 denotes the highest marginal cost, a rank order of 2 denotes the next highest marginal cost and a rank order of 3 denotes the lowest marginal cost.

Source: M.B. Cairns and B.D. Kirk, Canadian For-Hire Trucking and the Effects of Regulation: A Cost Structure Analysis, CTC, (1980), p. 185.

B. Rate Differentials between Intra and Interprovincial Shipments

In the above rate level analysis, the impact of trucking regulation is investigated by comparing rate levels between provinces with different levels of regulatory controls. Here, the issue will be further examined by comparing the rate differentials between intra and interprovincial shipments of the three provinces. It is hoped that some regulatory impact could be detected through the comparisons of intra and interprovincial trucking rates because in Alberta, intraprovincial trucking operation is totally unregulated while interprovincial trucking is subject to the entry regulation and may be affected by the rate regulations of the destination provinces. Since in both Québec and Ontario, intra and interprovincial shipments are subject to the same regulatory control, the rate differentials between the two groups of traffic may be attributed to different commodity mix, intermodal competition or cross-subsidization. Overall, the intention is to find some diversity in the intra and inter rate differentials among the three provinces.

The rate differentials between the intra and the interprovincial shipments are estimated by the regression coefficients of the INEX dummy variables; the relative rate levels can be measured by taking the exponential of the coefficient value. For example, the coefficient on the INEX dummy variable of Québec LTL total is -0.204 which indicates that in Québec, the revenue per ton-mile of the LTL extra-provincial shipments is exp (-0.204) = 0.82 (or 82%) of the rate of intraprovincial shipments. In general, a positive significant coefficient on the INEX dummy variable means that the rate of interprovincial shipments is higher than the rate of intraprovincial shipments, while a negative significant coefficient indicates the reverse.

The coefficients on the INEX variables of both the TL and LTL models of the three provinces are summarized in Table 5.22. Three main points derived from the table are described below:

First of all, the Alberta entry regulation on interprovincial trucking operation has no pronounced effect on the rate levels of the intra and interprovincial shipments. In LTL segments, only one INEX coefficient, that is in the rate model of Food & Beverages, is found statistically significant but it is negative. This indicates that in the movement of food products by LTL, the rates of interprovincial shipments which are subject to entry control are lower than the rates of intra provincial shipments which are unregulated. On the other hand, in the TL segments, two out of four coefficients on INEX variables are found positive and significant. Therefore, there is no predominant evidence of either the positive or the negative effect of regulation on rate levels.

Table 5.22

RATE LEVEL COMPARISONS BETWEEN INTRA AND INTERPROVINCIAL SHIPMENTS BY TL/LTL AND BY PROVINCES BASED ON REGRESSION COEFFICIENTS ON THE INEX VARIABLES

LTL	Québec	Ontario	Alberta
Total	-0.204*	0.063	0.130
Food and Beverages	-0.295*	-0.017	-0.757*
Fabricated Materials	-0.164*	-0.063	0.279
End Products	-0.618	-0.077	0.118
TL			
Total	0.162*	0.031	0.180
Food and Beverages	0.215	-0.119*	0.490*
Fabricated Materials	0.252*	0.040	0.127*
End Products	-0.130	-0.282*	-0.073

* Signifies significant coefficient with a t value greater than 2.

A negative sign indicates that intraprovincial shipments have a higher rate level than interprovincial shipments and vice versa.

Second, in Ontario, the rate differential between intra and interprovincial LTL shipments is found to be insignificant; and only two groups of commodities in TL shipments show that the rates of interprovincial shipments are somewhat below the rates of intraprovincial shipments.

Finally, the results for Québec are quite different from the results for the other two provinces in the LTL segment. All Québec LTL groups show lower rates with interprovincial shipments and three out of the four groups indicate the rate differentials to be significant. However, in the TL segment, the results for Québec are similar to those for Alberta.

●Conclusion

Overall, the rate differentials between intra and interprovincial shipments are not significant in Ontario and Alberta. Only in Québec does a pronounced rate differential appear in the LTL segment, with interprovincial shipments having lower rates than intraprovincial shipments. There is no evidence to support the assumption that the interprovincial trucking entry control in Alberta has an adverse effect on rates. On the other hand, there is no proof that free entry, as exists for intraprovincial trucking in Alberta, might lead to "destructive competition" and induce substantially lower rates.

5.3.3 Rate Structure Analysis

Studies of the impact of economic regulation on trucking rate structures have concentrated on the issue of cross-subsidization between small and large shipments which in some more recent studies, is specifically referred to as cross-subsidization between LTL and TL traffic. The hypothesis is that economic regulation leads to cross-subsidization. However, economists have not reached a concensus on whether the cross-subsidization, felt to be taking place in a regulated environment, takes the form of LTL shipments subsidized by TL shipments or the other way around. Besides, the conclusions on TL-LTL cross-subsidization are so far conjectured rather than proven for the following four reasons:

(a) The cost structures of TL and LTL shipments are quite different. LTL traffic involves much higher handling costs than TL traffic in pick-up and delivery and terminal operations. While few empirical studies provide comparisons between the cost structures of TL and LTL traffic, it has been shown in the Canadian Transport Commission study on trucking cost structures (mentioned earlier) that the ratios of TL to LTL marginal costs of the provinces differ widely. Therefore, the relative ratio of TL to LTL rates between provinces alone does not provide strong evidence for the presence of cross-subsidization.

(b) Although the trucking industry cannot be distinctly segmented into TL and LTL carriers, it is known that some carriers are heavily concentrated on TL traffic and others on LTL traffic.* Therefore, cross-subsidization cannot be supported because the implication is that one group of carriers subsidizes the other group of carriers in the trucking industry.

(c) TL and LTL rates are determined by separate rating systems. For instance, the Tariff Bureau plays a more important role in the determination of LTL rates than TL rates.

(d) The rate structures of TL and LTL are different. As is found in this study, in LTL, weight and distance play equally important roles in rates while in TL, weight has less effect than distance.

All in all, it is difficult to determine cross-subsidization between TL and LTL from the rate analysis without some detailed analysis of the cost structure of the two types of traffic. Consequently, in this study, we will not attempt to compare the TL and LTL rate levels; instead, we will investigate the issue of cross-subsidization between small and large shipments in LTL and TL markets, respectively.

The approach adopted here is to compare the relative size of the coefficients of the weight variables of the provinces. Since all the weight coefficients are negative, indicating that revenue per ton-mile goes down with large shipments, a larger coefficient in absolute value will mean a steeper rate curve. Given that the cost curve is also downward to the right, the motor carrier industry may adopt any of the following three possible pricing strategies. First, the price curve is always above the cost curve; there is no cross-subsidization but the gap (the profit margin) may be greater for some types of traffic than for others. Second, a very flat rate curve in terms of the size of shipment may indicate that for a small shipment the rate is below marginal cost; in this case large shipments subsidize small shipments. Finally, on the other extreme, a steep rate curve may imply that the rate for a large shipment is below marginal cost and that small shipments subsidize large shipments. The concept of cross-subsidization between small and large shipments is further illustrated in Figure 5.17.

The elasticities of the rate curves can be compared between the provinces by use of Figures 5.1 to 5.4 for LTL and Figures 5.9 to 5.13 for TL as well as the results of weight coefficients shown in Tables 5.11 to 5.18. However, it should

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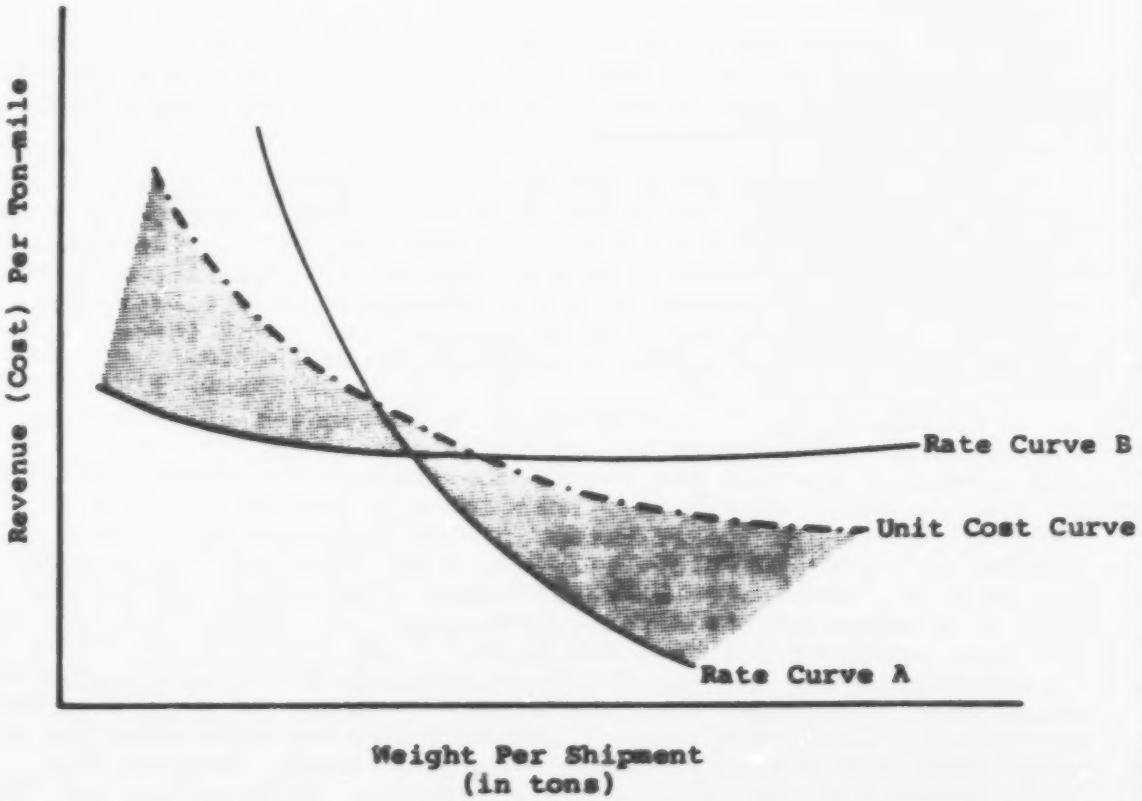
* D. Wyckoff and D. Maister, The Motor-carrier Industry, 1977.

Figure 5.17

AN ILLUSTRATION OF THE CONCEPT OF CROSS-SUBSIDIZATION BETWEEN LARGE AND SMALL SHIPMENTS



NOTE: The shaded areas represent the unprofitable freight which is cross-subsidized by other market segments. Given the cost curve, rate curve A implies that large size shipments are subsidized by small shipments while rate curve B indicates the opposite.

be noted that the shapes of the cost curves resulting from the earlier Canadian Transport Commission trucking study cannot be used directly to compare the shapes of rate curves in this study because the average shipment weight was not used as an explanatory variable for the cost. The conclusions obtained from the empirical results of LTL and TL are given below.

First of all, in LTL, the results of Québec and Alberta are very close while the rate curves over the ranges of shipment weights in Ontario are flatter than the comparable curves of the other two provinces. For instance, the shipment weight coefficients of LTL totals of the three provinces are:

Québec	Ontario	Alberta
-0.527	-0.271	-0.562

Therefore, cross-subsidization in Ontario, if there is any, tends to take the form of large LTL shipments subsidizing small LTL shipments.

Second, in all three provinces the weight coefficients in TL rate models by commodity groups are less significant than those in LTL rate models. Particularly, the weight coefficients of the TL Food & Beverage group are found statistically insignificant in both Québec and Alberta. That is, in these two provinces, the revenues per ton-mile on moving food products by TL are not greatly affected by the shipment size. Between the provinces, Ontario weight coefficients in TL rate models are, except for the food group, substantially smaller (in absolute value terms) than the comparable coefficients for Alberta. Québec's weight coefficients are greater than Ontario's but only two out of four are greater than Alberta's. Therefore, unless Ontario TL cost curves by shipment sizes are indeed flatter than those of the other two provinces, the results show more tendency towards cross-subsidization in Ontario, with large TL shipments subsidizing small TL shipments. Furthermore, it is worth noting that the weight coefficient of Québec truckload End Products is extremely high in absolute value compared to both Ontario's and Alberta's, i.e., -0.9333. Therefore, this could be an indication that the small TL shipments of End Products are currently subsidizing large TL shipments in Québec.

•Conclusion

In this subsection, the issue of cross-subsidization between small and large shipments is examined separately in TL and LTL markets. In LTL, the variation of rates in terms of shipment size is similar in Québec and Alberta despite the fact that different regulatory systems are adopted in the two provinces. The rate differentials between small and large shipments are less in Ontario; assuming that the marginal cost of moving small shipments is greater than moving large shipments, this might be explained as cross-subsidization of

small LTL shipments by large LTL shipments. On the other hand, in the TL segment, one extreme value on the weight coefficient is found in the Québec End Products group. Provided that the marginal costs of moving TL End Products in Québec do not decrease towards large shipments as dramatically as rates, the large weight coefficient may be explained as cross-subsidization of large TL shipments by small TL shipments.

5.3.4 The Small Community Issue

The impact of regulation on for-hire trucking services to small communities is one of the major concerns of recent examinations of trucking regulation. Two questions often raised in debates over motor-carrier regulations are whether the service to small communities will deteriorate in the absence of regulation and whether the regulatory regimes have enforced cross-subsidization between large and small community shippers as a result of rate and route controls. On the one hand, the proponents of regulation argue that without any regulatory control, the carriers would either withdraw services from unprofitable small communities or raise their prices. On the other hand, the opponents claim that regulation has promoted unreasonable cross-subsidization. Although a direct comparison of rates to and from small and large communities is hindered by the lack of available data, the differing regulatory structures existing in the provinces of Canada have made it possible to perform comparisons of rate structures between regulated and unregulated provinces in terms of the population of the origin and the destination of the shipments. In this section, the empirical results of the effect of the population variables on rates in Alberta, Ontario and Québec will be presented.

Table 5.23 summarizes the regression coefficients on the population variables of the origin and the destination of the shipments. These coefficients are obtained from the rate models described in Section 5.3.1. In the table, a positive significant coefficient on the POPO variable would mean that rates on shipments <u>from</u> highly populated communities are higher than rates on shipments from less populated communities. The same logic can be applied to the POPD variable except that it represents the effect of population size on rates of shipments <u>to</u> small or large communities.

At first glance, it is rather interesting to find that both the variables of the population of the origin and the destination in all three provinces are predominated by positive significant coefficients. The results indicate that, <u>other things being equal</u>, rates on shipments from large communities to large communities are higher than rates on shipments from small communities to small communities. The relative rate levels between shipments from large to small communities and shipments from small to large communities will depend on <u>the relative size of the coefficients of POPO and POPD variables</u>. For example,

Table 5.23

COEFFICIENTS ON VARIABLES OF THE POPULATION OF THE ORIGIN (POPO) AND DESTINATION (POPD) OF THE SHIPMENTS

	Québec		Ontario		Alberta	
	POPO	POPD	POPO	POPD	POPO	POPD
LTL						
Total	0.059*	0.049*	0.102*	0.073*	0.024*	0.004
Food and Beverages	0.102*	0.014	0.079*	0.021*	-0.004	0.017
Fabricated Materials	0.066*	0.037*	0.124*	0.082*	-0.001	0.057*
End Products	0.043*	0.050*	0.085*	0.034*	0.021*	-0.012
TL						
Total	0.038*	0.063*	0.043*	0.037*	0.046*	0.017*
Food and Beverages	0.064*	0.017	0.049*	0.039*	0.110*	-0.021
Fabricated Materials	0.032*	0.066*	0.034*	0.041*	0.015*	0.001
End Products	0.037	0.070*	0.031*	-0.004	0.062*	0.018

* Indicates the significant coefficients whose t values are greater than 2.

the following rank orders of traffic flows in terms of highest revenue per ton-mile are derived from results of the rate models of total LTL shown in Table 5.23.

Traffic Flows	Rank Order in Terms of Highest Rate*
Large communities to large communities	1
Large communities to small communities	2
Small communities to large communities	3
Small communities to small communities	4

*All independent variables except POPO and POPD are held fixed.

Given the firms' average cost, the above rank orders of rates clearly indicate that shipments between large communities are much more profitable than shipments between small communities. This may also be an indication of cross-subsidization between shippers from large and small communities, assuming that the rate on traffic between small communities, which is the lowest in the rate rank, is below marginal cost.

It is also noted from Table 5.23 that in the LTL segment, POPO is more important than POPD in terms of the relative size of the coefficients of these variables. As a result, ceteris paribus, shipments from large to small communities show higher rates than shipments from small to large communities. In addition to the above hypothesis that shippers in large cities subsidize those in small towns, there are two other possible explanations. One, is that commodities originating from highly populated areas, e.g., large cities, generally have a higher value than goods from low population density areas, thus, the rate rank order is consistent with the value of service pricing assumption; and the other is that trucking service from large to small communities tends to have more empty backhauls than service from small to large communities, therefore, the former is charged higher rates than the latter.

Although, in the example given above, the three provinces have shown the same rank order in rates of LTL traffic flows between small and large communities, the rate structure in Alberta is somewhat different from that in Québec and Ontario. First, the sizes of the coefficients in Alberta are very much smaller than those in the other two provinces. Secondly, the POPD variable of LTL total for Alberta is not statistically significant. In other words, the cross-subsidizations between small and large community shippers, although they have the same pattern in the three provinces, are less significant in Alberta.

However, more detailed analysis by commodity groups indicate wider differences between Alberta and the other two provinces. As shown in Table 5.24, there are several cases in Alberta where rates on shipments either to or from small communities are higher, though the rate differentials between large and small communities are not significant.

Generally speaking, in LTL, rate differentials between large and small communities are higher in Ontario than in Québec. However, in TL, the comparison between Québec and Ontario is more difficult because in half of the cases, Québec shows higher rate differentials and in the other half the rank is reversed.

- Conclusion

In conclusion, rate differentials, or cross-subsidizations between large and small communities are found to be most significant in Ontario, next in Québec and least in Alberta. Furthermore, this phenomenon is more pronounced in the LTL market than in the TL market.

Table 5.24

RANK ORDER OF THE LTL TRAFFIC FLOWS BETWEEN LARGE AND SMALL COMMUNITIES IN TERMS OF HIGHEST RATES BY COMMODITY GROUPS

Traffic Flows	Food and Fabricated Materials			End Products		
	Québec	Ontario	Alberta	Québec	Ontario	Alberta
Large communities to large communities	1	1	3	1	1	2
Large communities to small communities	2	2	4	3	2	1
Small communities to large communities	3	3	1	2	3	4
Small communities to small communities	4	4	2	4	4	3

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APPENDICES

Appendix A

ASSIGNMENT OF POPULATION COUNTS

Population counts were appended to the TOD shipment file for all origin and destination place names. The population figures attached were taken from the 1976 Census, and they were assigned on the basis of the metropolitan-nonmetropolitan codes or the Standard Geographical Classification (SGC) codes which already existed on the TOD shipment file. The types of areas identified and assigned population counts by these two sets of codes included census metropolitan areas (CMA's), census agglomerations (CA's), census subdivisions and particular places within a given subdivision.

The Standard Geographical Classification* is a way of identifying and coding geographical areas. The first list of SGC codes was produced by Statistics Canada in 1966. These were six digit codes. The first two digits identify provinces or territories, the third and fourth represent census subdivisions. A major revision to the classification occurred just prior to the 1976 Census. The census subdivision codes were expanded from two to three digits in all areas and resulted in a system of seven digit codes.

The SGC codes contained in the 1975 TOD file were six digit codes, and it was necessary to update these codes to the 1976 seven digit codes in order to assign 1976 Census population figures. In the process of updating these codes, however, it

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* For more complete details, cf. Statistics Canada, Standard Geographical Classification Manual: Volume I-The Classification, (1976), Catalogue No. 12-554.

was discovered that some SGC codes were miscoded. Since most of the origin-destination mileages were calculated on the basis of the SGC codes, the mileages on these shipment records had to be recalculated.*

Each origin and destination place on the TOD file contains a code indicating whether the place is part of, a CMA or a CA. Places identified as CMA's were assigned the entire CMA population count without further reference to the SGC codes, and places identified as part of a CA according to the SGC code were assigned the entire CA population count.

The remaining places, after assigning population figures to CMA and CA places, were assigned census subdivisions or in some cases particular place name population counts.

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* These mileage errors are also discussed in M.B. Cairns, and B.D. Kirk, Canadian For-Hire Trucking and the Effects of Regulation: A Cost Structure Analysis, Canadian Transport Commission.

Appendix B

PRINCIPAL COMPONENT ANALYSIS AS APPLIED TO THE SERVICE CHARACTERISTICS OF SHIPMENTS

The technique of principal component analysis is a general statistical technique which has proven useful* in analyzing collections of units (in this case truck shipments) for which a sequence of measurements or characteristics have been recorded with the intent of identifying outlying units and significant clusters of units.

Let us represent the p operating characteristics or variables under investigation in section 4.2 as a vector $\underset{\sim}{y}$

$$\underset{\sim}{y} = \begin{pmatrix} y_1 \\ y_2 \\ \cdot \\ \cdot \\ \cdot \\ y_p \end{pmatrix}$$

and then construct a (p x n) matrix Y

$$Y = (\underset{\sim}{y}_1 \; \underset{\sim}{y}_2, \ldots, \underset{\sim}{y}_n)$$

where each of the n columns corresponds to a truck shipment. The basic idea of principal component analysis is to describe the dispersion of the array of n points in p-dimensional space by introducing a new set of orthogonal linear coordinates so that the sample variances of the given points, with respect to these derived coordinates, are in decreasing order of magnitude. Thus, the first principal component is such that

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* For some examples see R. Gnanadesikan, Methods for Statistical Data Analysis of Multivariate Observations, John Wiley and Sons, New York, 1977.

the projections of the given points onto it have maximum variance among all possible linear coordinates; the second principal component has maximum variance subject to being orthogonal to the first and so on. A two dimensional plot of the first two principal components is useful in highlighting outlying points and any significant clustering of the points.

Since the principal components are not invariant under separate scaling of the original coordinates, we first scale each row of matrix Y to have unit variance; this is particularly important since y_1 to y_6 are in physical or monetary units while y_7 is an indicator variable. Next the correlation matrix R is constructed:

$$R = (r_{ij})$$

$$r_{ij} = \frac{s_{ij}}{\sqrt{s_{ii} s_{jj}}}$$

$$s_{ij} = \frac{1}{n-1} \sum_{k=1}^{n} (y_{ik} - \bar{y}_i) \quad (y_{jk} - \bar{y}_j)$$

$$\bar{y}_i = \frac{1}{n} \sum_{k=1}^{n} y_{ik}$$

We now consider the spectral decomposition of the matrix R

$$R = A \Gamma A'$$

where Γ is a diagonal matrix $\Gamma = \text{diag}\ (\lambda_1, \lambda_2, \ldots, \lambda_p)$ with λ_i the eigenvalues of R such that $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_p > 0$, and A is an orthogonal matrix $A = (\underset{\sim}{a}_1, \underset{\sim}{a}_2, \ldots, \underset{\sim}{a}_p)$ with $\underset{\sim}{a}_i$ the corresponding eigenvectors of R. The principal component's transformation of the data is then given by

$$Z = A' \ (Y - \bar{Y})$$

where $\bar{Y} = (\bar{y}\ \bar{y}\ \ldots\ \bar{y})$ and a plot of the first two principal components is given by a plot of the first two rows of Z. Specifically,

$$z_1 = a_{11}\, y_1^* + a_{12}\, y_2^* + \ldots + a_{1p}\, y_p^*$$

$$z_2 = a_{21}\, y_1^* + a_{22}\, y_2^* + \ldots + a_{2p}\, y_p^*$$

where y_i^* are the original variables y_i rescaled to unit variance and shifted to zero mean. The coefficients $\{a_{1i}\}$ and $\{a_{2i}\}$ are useful in interpreting the relative importance of the original variables to the first two principal components while the eigenvalues λ_1 and λ_2 are useful in interpreting the overall importance of the first two principal components themselves; since the sum of all p eigenvalues is p itself, the ratio $(\lambda_1 + \lambda_2)/p$ represents the percentage of variation depicted by the first two principal components.

Individual principal component analyses were conducted for shipments by commodity group and by province. The results of the analyses of commodity group I (Live Animals) by province appear in Chapter 4; the coefficients of the first two principal components of the analyses of commodity groups II to V by province appear in Table A.1 with the corresponding principal component plots appearing in Figures A.1 to A.12. Significant clustering of shipments or the appearance of outlying shipments has been highlighted on the plots where appropriate and overall results may be summarized as follows.

Figures A.1, A.2 and A.3 for commodity group II indicate a fairly homogeneous collection of shipments in each province. Notice the single outlying shipment in Ontario of other food preparations (PCA symbol = 6 corresponding to SCC code = 146; see Table 4.3) and the marginal separation of shipments in Alberta into two clusters according to the first principal component; the cluster with smaller values of the first principal component consists primarily of shipments of

cereal grains, unmilled, and other bakery products (PCA symbols = 3 and 4 corresponding to SCC codes = 61 and 64) while the cluster with larger values of the first principal component consists primarily of shipments of meat, vegetables and other food preparations (PCA symbols = 1, 5 and 6 corresponding to SCC codes = 11, 91 and 146). Examination of the coefficients of the first two principal components for commodity group II in Table A.1 reveals the following: shipments in all three provinces with large values of the first principal component may be characterized as high weight and low cost revenue shipments (in Alberta, the important characteristics are the same but the direction of the first principal component is reversed, leading to opposite signs of the coefficients; this is an artifact of the computer software and since it is the orientation and not the direction of the principal components that is of importance, this may be disregarded); in addition, shipments in all three provinces have the second principal component related to distance.

Figures A.4, A.5 and A.6 for commodity group III reveal four distinct outlying shipments in Alberta. In Québec, there appears to be a separation of shipments of sand, gravel and crude stone (PCA symbol = 3 corresponding to SCC code = 276) into two clusters according to the first principal component, with the remaining shipments being positioned predominantly between the two clusters; alternatively, in Ontario, shipments of sand, gravel and crude stone comprise a single cluster with correspondingly large values of the first principal component while remaining shipments have smaller values of the first principal component. Examination of the coefficients of the first two principal components for commodity group III in Table A.1 reveals that the combination of important characteristics differs by province although revenue, weight and distance feature repeatedly.

Figures A.7, A.8 and A.9 for commodity group IV reveal in all three provinces a dense cluster of numbered commodities

(PCA symbols 1 through 8) together with a secondary cluster of other commodities (PCA symbol = *). Examination of the coefficients of the first two principal components for commodity group IV in Table A.1 reveals that shipments in all three provinces with large values of the first principal component may be characterized as high weight and low cost revenue shipments (these are the characteristics of the cluster of numbered commodities) while the shipments in all the provinces have the second principal component related to distance.

Figures A.10, A.11 and A.12 for commodity group V reveal only a marginal separation in Alberta according to the first principal component; large values of the first principal component are associated with shipments of engines and turbines (PCA symbol = 1 corresponding to SCC code = 502), middle-range values are associated with shipments of passenger automobiles and chassis and trucks, truck chassis and truck tractors (PCA symbols = 2 and 3 corresponding to SCC codes = 581 and 582) while low values are associated with the remaining commodities in the group. Examination of the coefficients of the first two principal components for all three provinces indicates that the first principal component is related to weight and revenue while the second principal component is related to distance and the population of the shipment destination.

Finally, the percentage of variation depicted by these principal component plots varies from a high of 70% to a low of 47% suggesting that for shipments in some commodity groups and provinces, much of the variation in service characteristics may be captured in a few measures such as weight, distance and revenues, while for other groups and provinces the situation is a little more complex.

Table A.1

THE COEFFICIENTS $\{a_{1i}\}$ AND $\{a_{2i}\}$ OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE ANALYSES CONDUCTED ON SHIPMENTS OF COMMODITIES IN GROUPS II TO V WITHIN THE THREE PROVINCES

				(REV) y_1^*	(COST) y_2^*	(WT) y_3^*	(DIST) y_4^*	(OPOP) y_5^*	(DPOP) y_6^*	(MONTH) y_7^*
Group II (food, feed, beverages and tobacco)	Québec n=1 000	λ_1=3.08	z_1	-0.41	-0.52	0.51	-0.27	-0.44	0.01	0.10
		λ_2=1.29	z_2	-0.51	-0.02	0.02	0.64	0.00	-0.12	-0.56
	Ontario n=2 050	λ_1=2.31	z_1	-0.59	-0.49	0.49	0.32	-0.26	0.04	0.03
		λ_2=1.28	z_2	0.18	0.10	0.25	-0.49	-0.65	0.45	0.20
	Alberta n=1 455	λ_1=3.33	z_1	0.50	0.52	-0.51	-0.03	0.31	0.33	0.11
		λ_2=1.58	z_2	-0.08	-0.05	-0.01	0.70	0.53	0.35	0.32

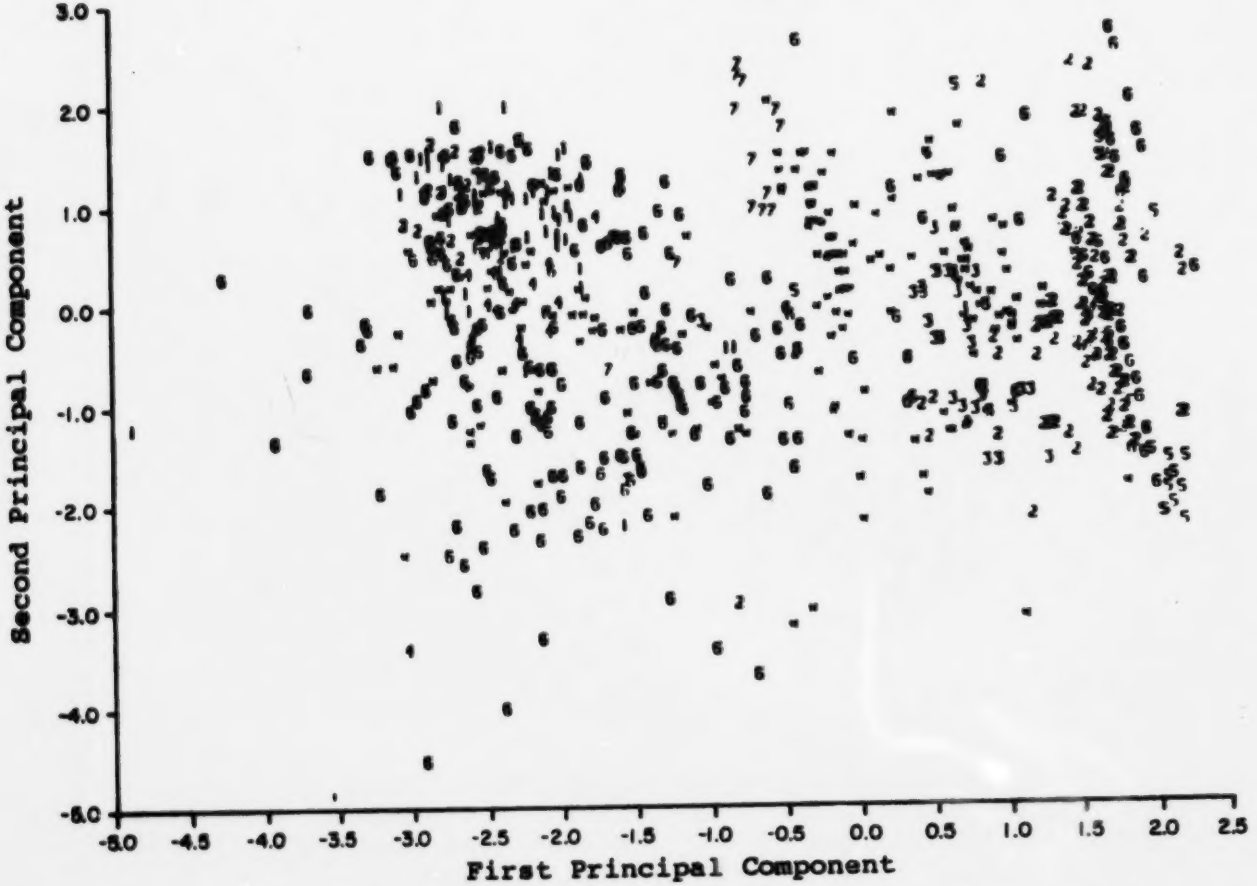
				(REV) y_1^*	(COST) y_2^*	(WT) y_3^*	(DIST) y_4^*	(OPOP) y_5^*	(DPOP) y_6^*	(MONTH) y_7^*
Group III (crude materials, inedible)	Québec n=279	λ_1=2.39	z_1	0.21	-0.41	-0.41	0.49	-0.35	-0.26	0.44
		λ_2=1.41	z_2	-0.71	-0.36	0.49	0.33	0.07	-0.11	0.08
	Ontario n=704	λ_1=2.54	z_1	-0.34	-0.43	0.51	-0.26	0.32	0.49	0.18
		λ_2=1.50	z_2	-0.61	-0.25	-0.15	0.65	-0.13	-0.16	0.29
	Alberta n=1 680	λ_1=2.22	z_1	-0.57	-0.49	0.22	0.52	0.10	0.13	-0.29
		λ_2=1.21	z_2	-0.08	-0.21	0.71	-0.27	-0.39	0.06	0.46

				(REV) y_1^*	(COST) y_2^*	(WT) y_3^*	(DIST) y_4^*	(OPOP) y_5^*	(DPOP) y_6^*	(MONTH) y_7^*
Group IV (fabricated materials, inedible)	Québec n=3 155	λ_1=2.62	z_1	-0.57	-0.50	0.52	0.07	-0.37	-0.13	0.03
		λ_2=1.17	z_2	-0.11	0.01	-0.17	0.56	0.15	-0.54	-0.57
	Ontario n=3 265	λ_1=2.05	z_1	-0.64	-0.49	0.47	0.34	-0.11	0.01	-0.02
		λ_2=1.23	z_2	0.08	-0.20	0.45	-0.64	0.40	0.43	-0.08
	Alberta n=3 719	λ_1=2.66	z_1	0.56	0.54	-0.56	-0.18	0.17	-0.13	0.03
		λ_2=1.17	z_2	-0.03	0.23	-0.25	0.59	-0.36	0.58	-0.27

				(REV) y_1^*	(COST) y_2^*	(WT) y_3^*	(DIST) y_4^*	(OPOP) y_5^*	(DPOP) y_6^*	(MONTH) y_7^*
Group V (end products, inedible)	Québec n=1 962	λ_1=1.89	z_1	0.68	0.14	-0.66	-0.07	0.26	0.06	0.07
		λ_2=1.43	z_2	-0.16	0.22	-0.12	0.63	0.32	-0.64	-0.02
	Ontario n=1 100	λ_1=2.09	z_1	0.65	0.32	-0.55	-0.29	0.28	-0.06	0.07
		λ_2=1.31	z_2	-0.06	0.15	0.36	-0.57	0.16	0.64	0.29
	Alberta n=1 617	λ_1=2.75	z_1	-0.56	-0.55	0.58	0.14	-0.17	0.08	0.02
		λ_2=1.24	z_2	0.00	0.10	-0.12	0.73	0.19	0.64	0.02

Figure A.1

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 1000 SHIPMENTS IN QUÉBEC CONSISTING OF COMMODITIES IN GROUP II (FOOD, FEED, BEVERAGES AND TOBACCO)



Note: The symbols used in this figure and the following figures are listed in Table 4.3 under PCA symbols.

Figure A.2

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 2 050 SHIPMENTS IN ONTARIO CONSISTING OF COMMODITIES IN GROUP II (FOOD, FEED, BEVERAGES AND TOBACCO)

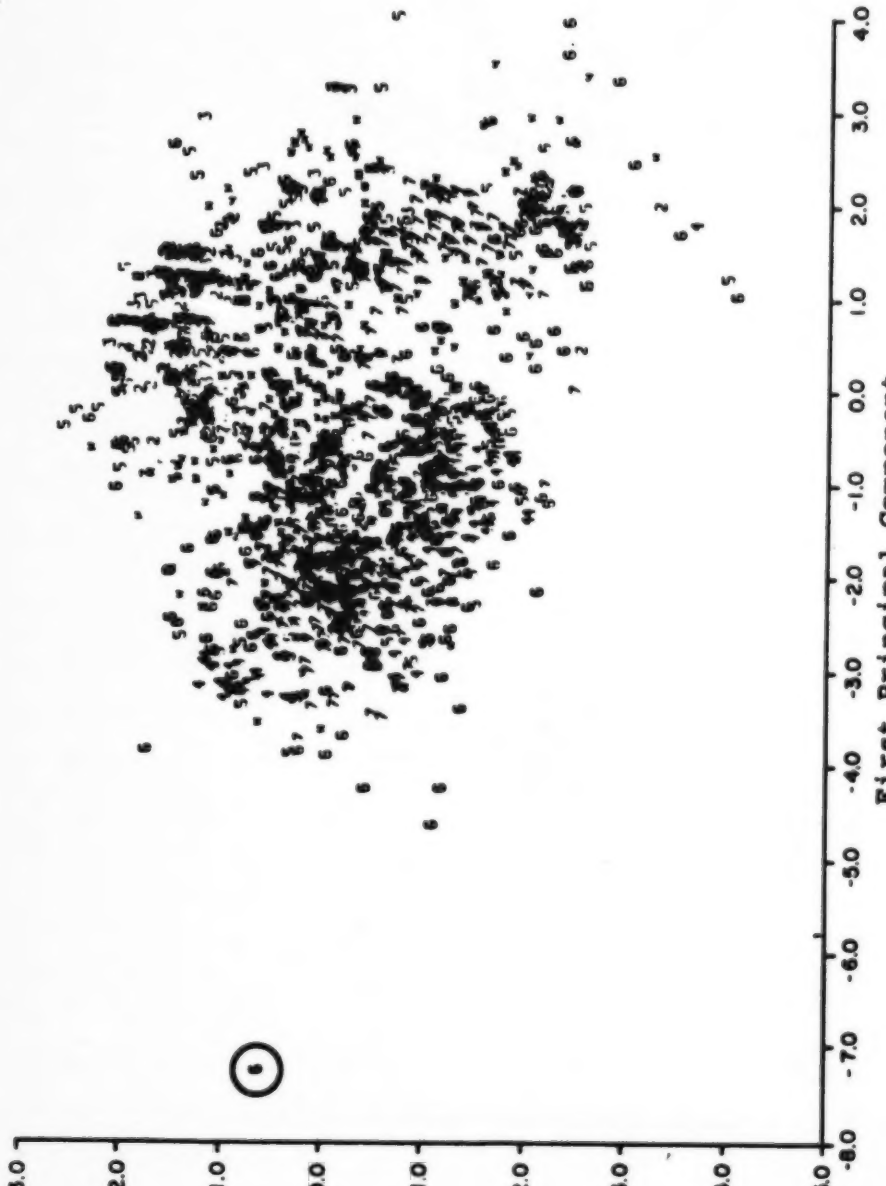


Figure A.3

A PLOT OF THE FIRST PRINCIPAL COMPONENTS FOR THE n = 1 455 SHIPMENTS IN ALBERTA CONSISTING OF COMMODITIES IN GROUP II (FOOD, FEED, BEVERAGES AND TOBACCO)

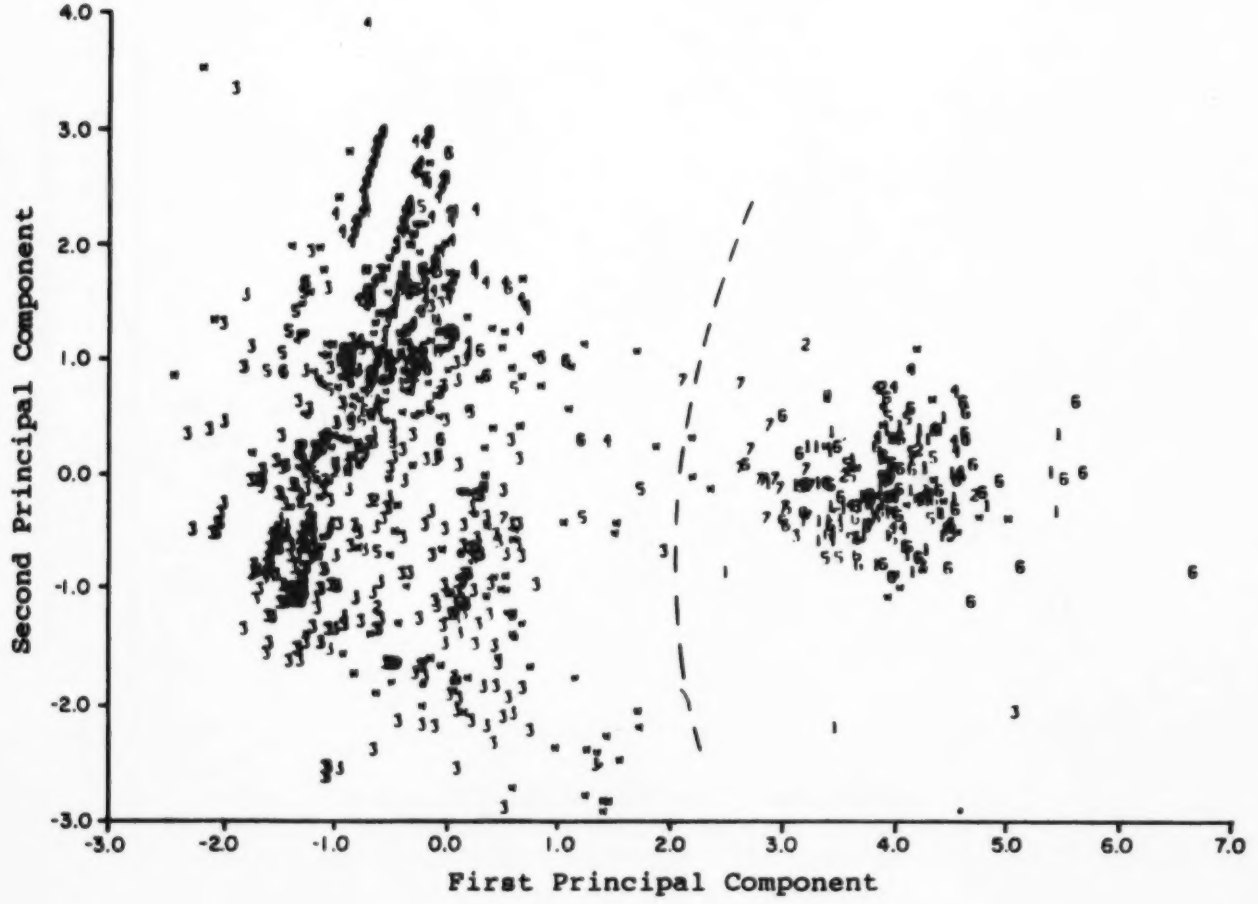


Figure A.4

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 279 SHIPMENTS IN QUÉBEC CONSISTING OF COMMODITIES IN GROUP III (CRUDE MATERIALS, INEDIBLE)

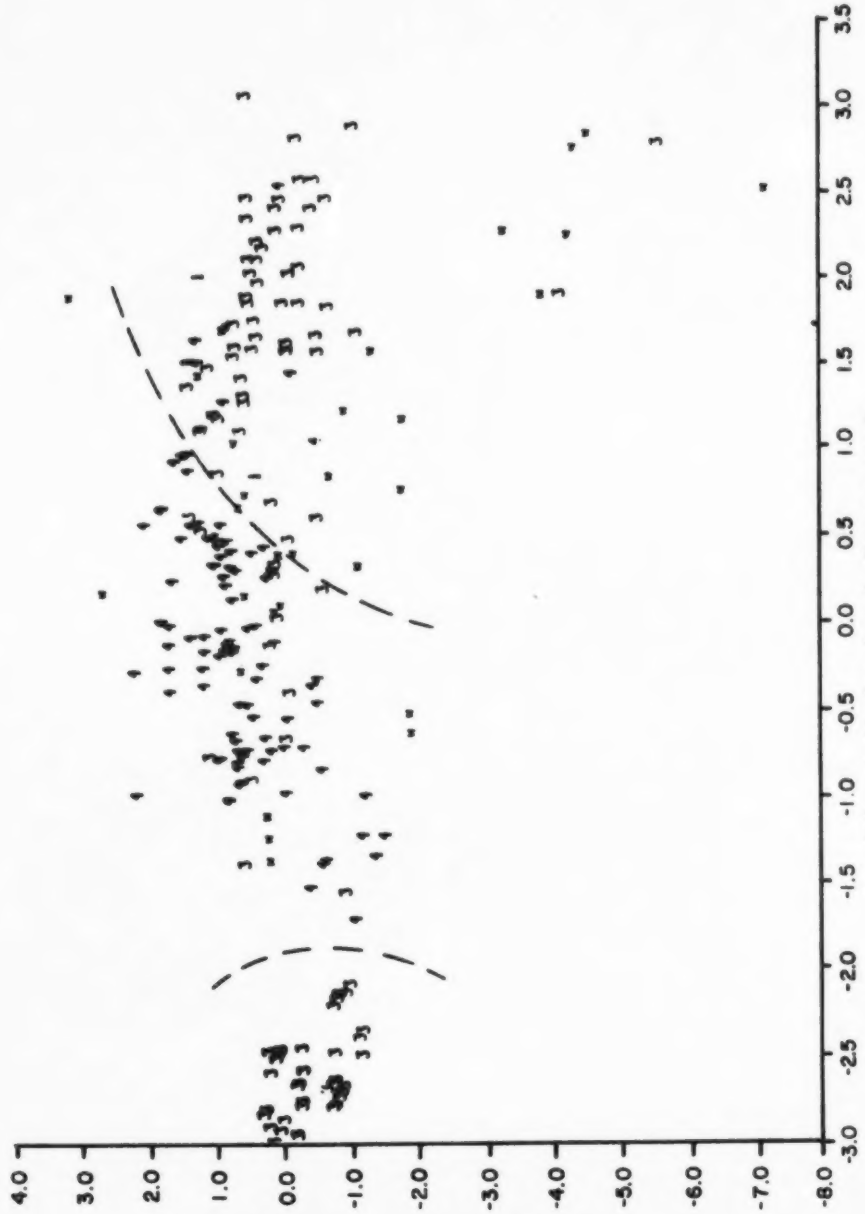


Figure A.5

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 704
SHIPMENTS IN ONTARIO CONSISTING OF COMMODITIES IN GROUP III
(CRUDE MATERIALS, INEDIBLE)

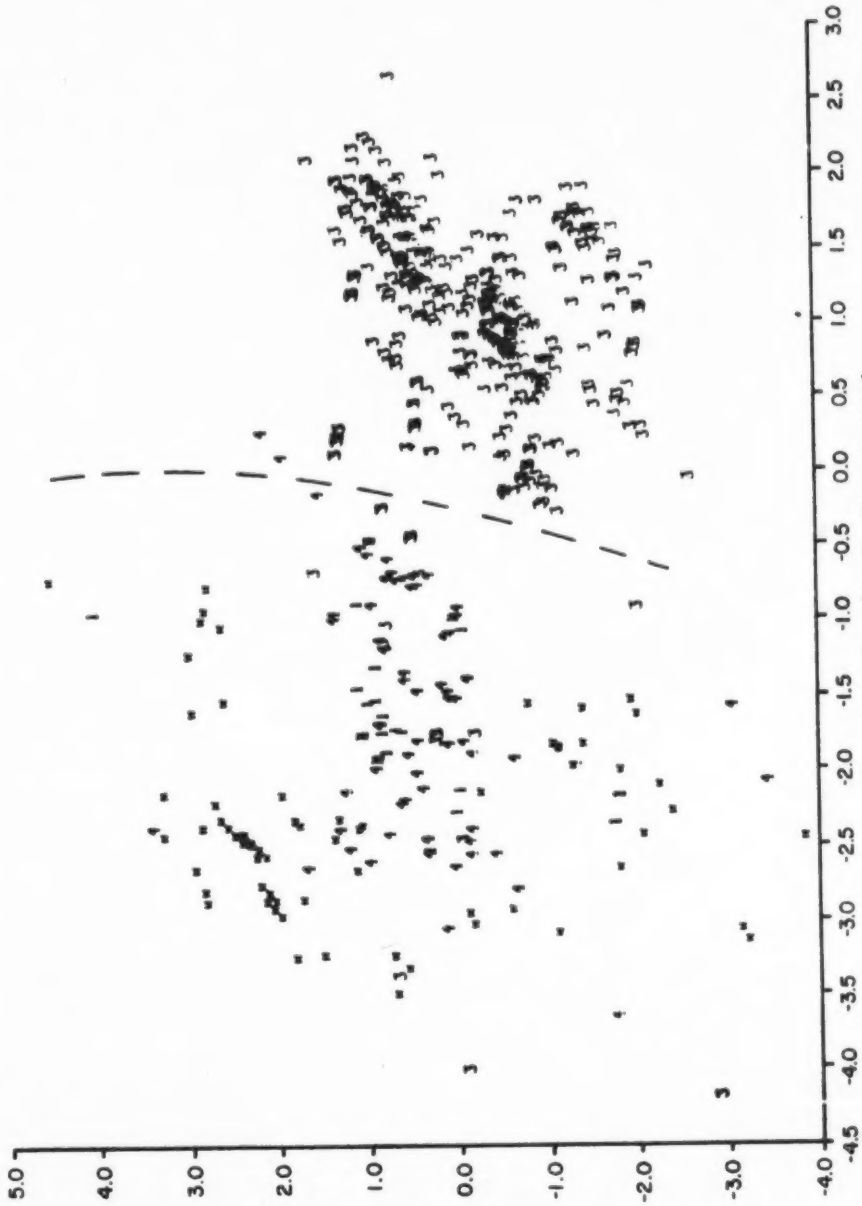


Figure A.6

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 1 680
SHIPMENTS IN ALBERTA CONSISTING OF COMMODITIES IN GROUP III
(CRUDE MATERIALS, INEDIBLE)

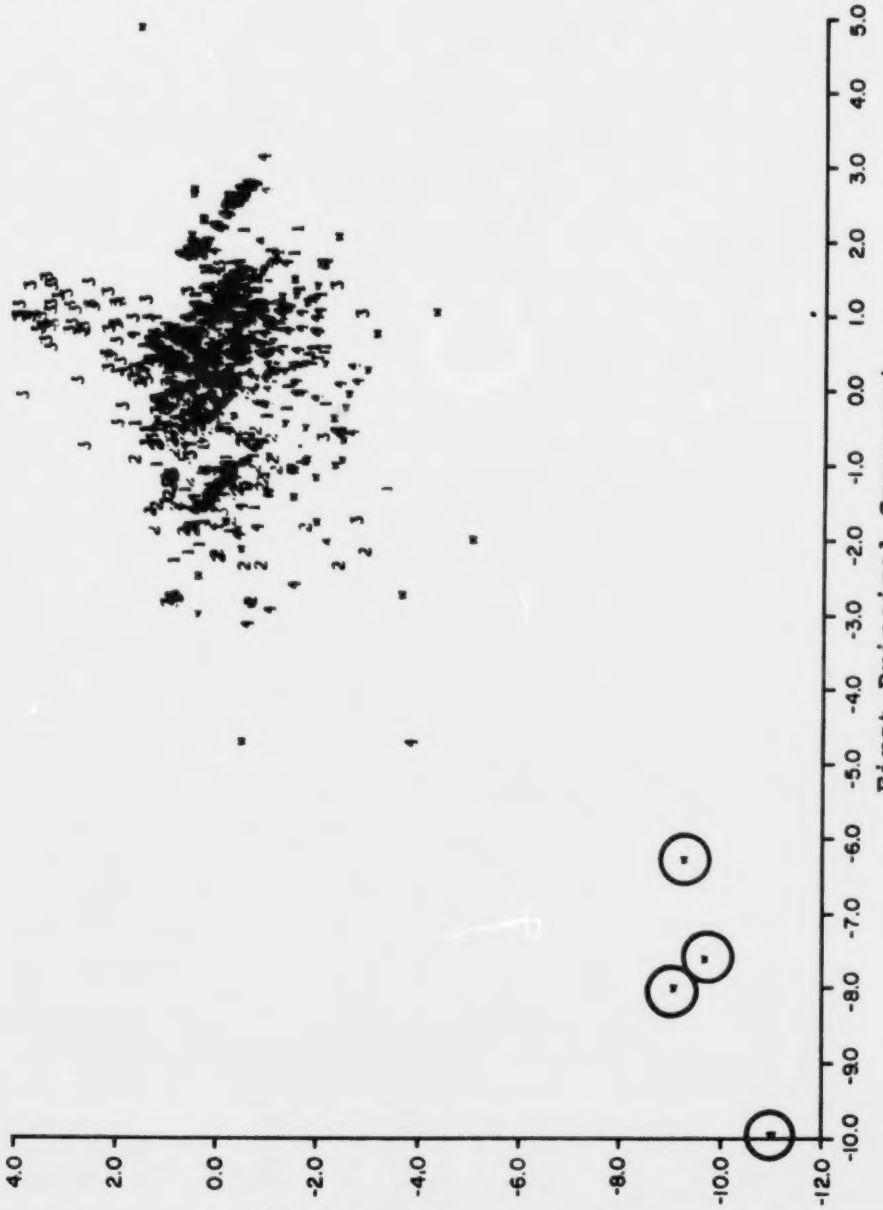


Figure A.7

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 3 155 SHIPMENTS IN QUÉBEC CONSISTING OF COMMODITIES IN GROUP IV (FABRICATED MATERIALS, INEDIBLE)

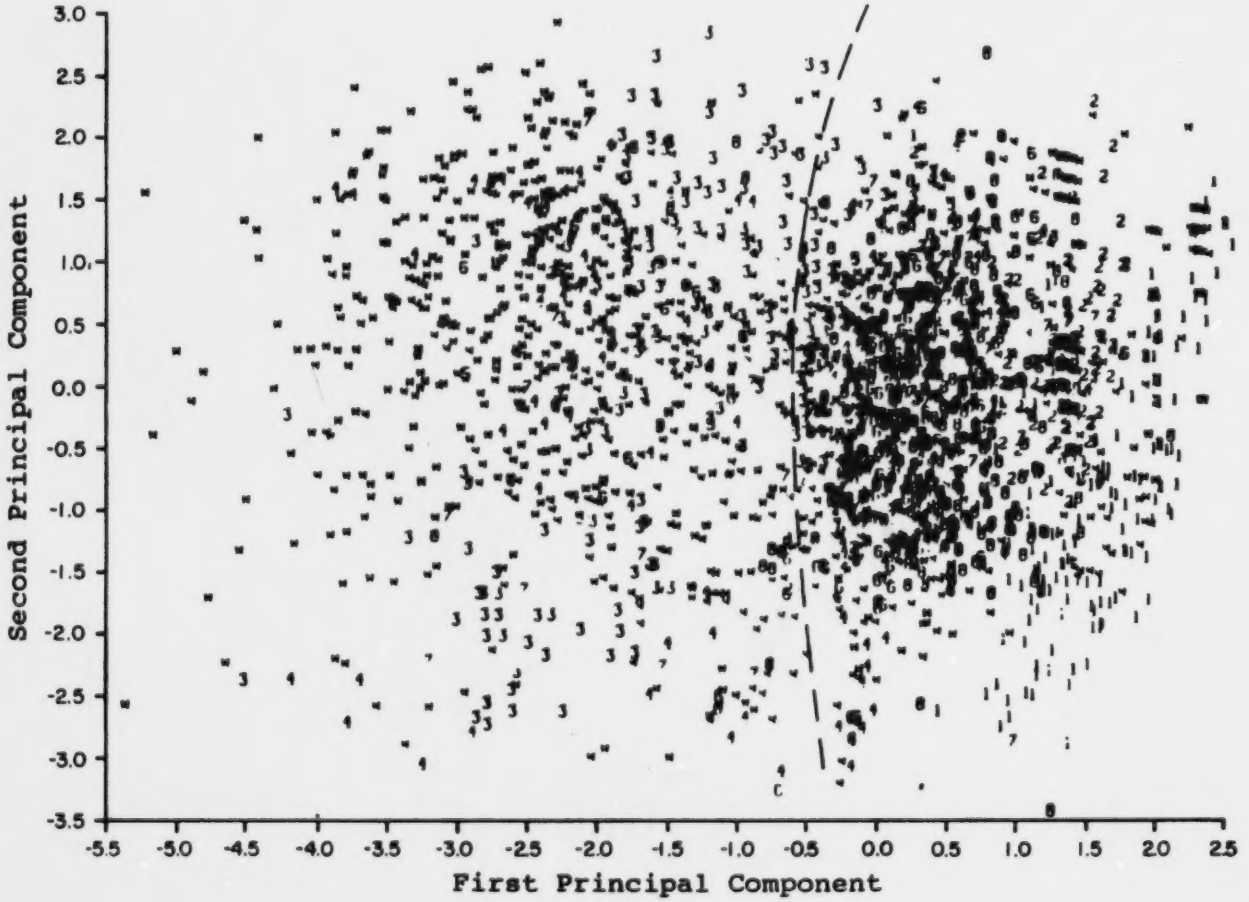


Figure A.8

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 3 265 SHIPMENTS IN ONTARIO CONSISTING OF COMMODITIES IN GROUP IV (FABRICATED MATERIALS, INEDIBLE)

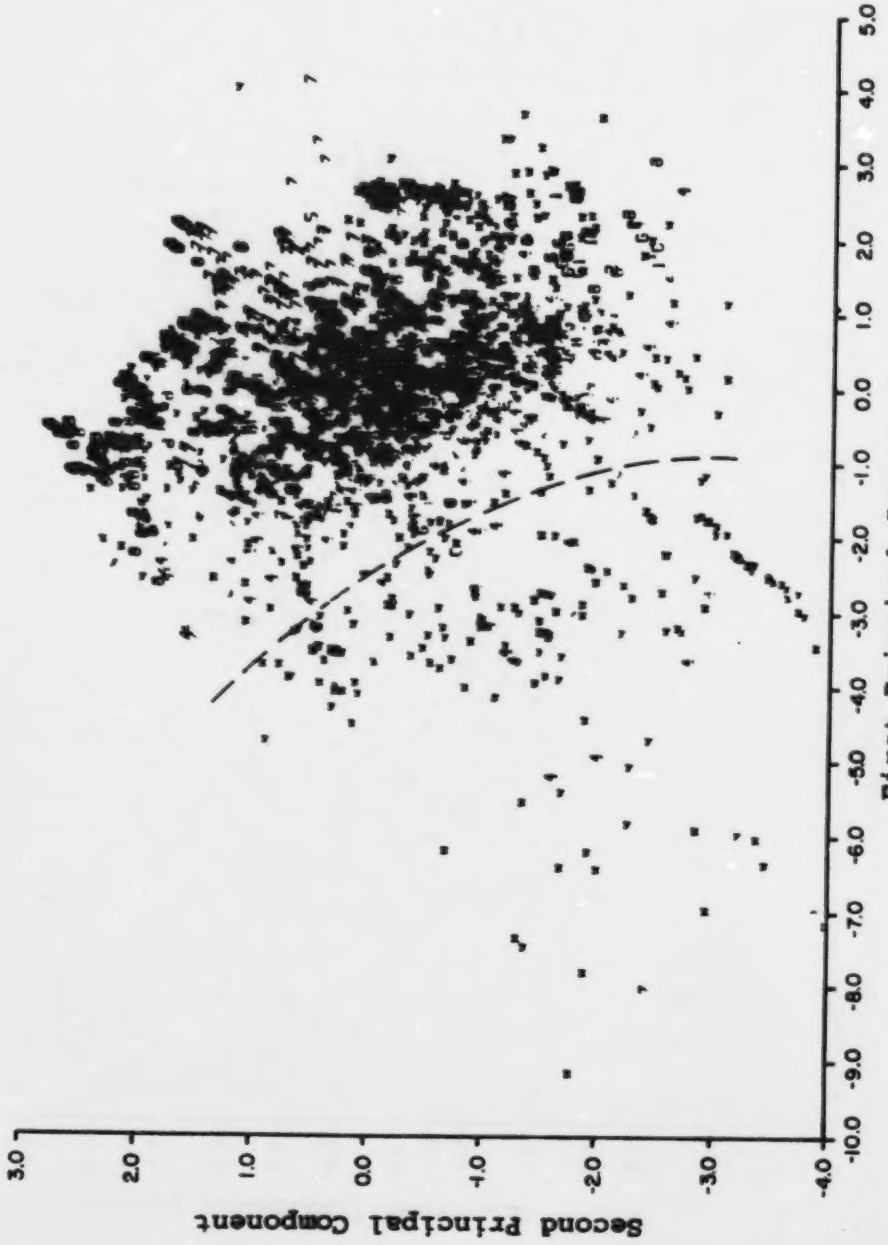


Figure A.9

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 3 719 SHIPMENTS IN ALBERTA CONSISTING OF COMMODITIES IN GROUP IV (FABRICATED MATERIALS, INEDIBLE)

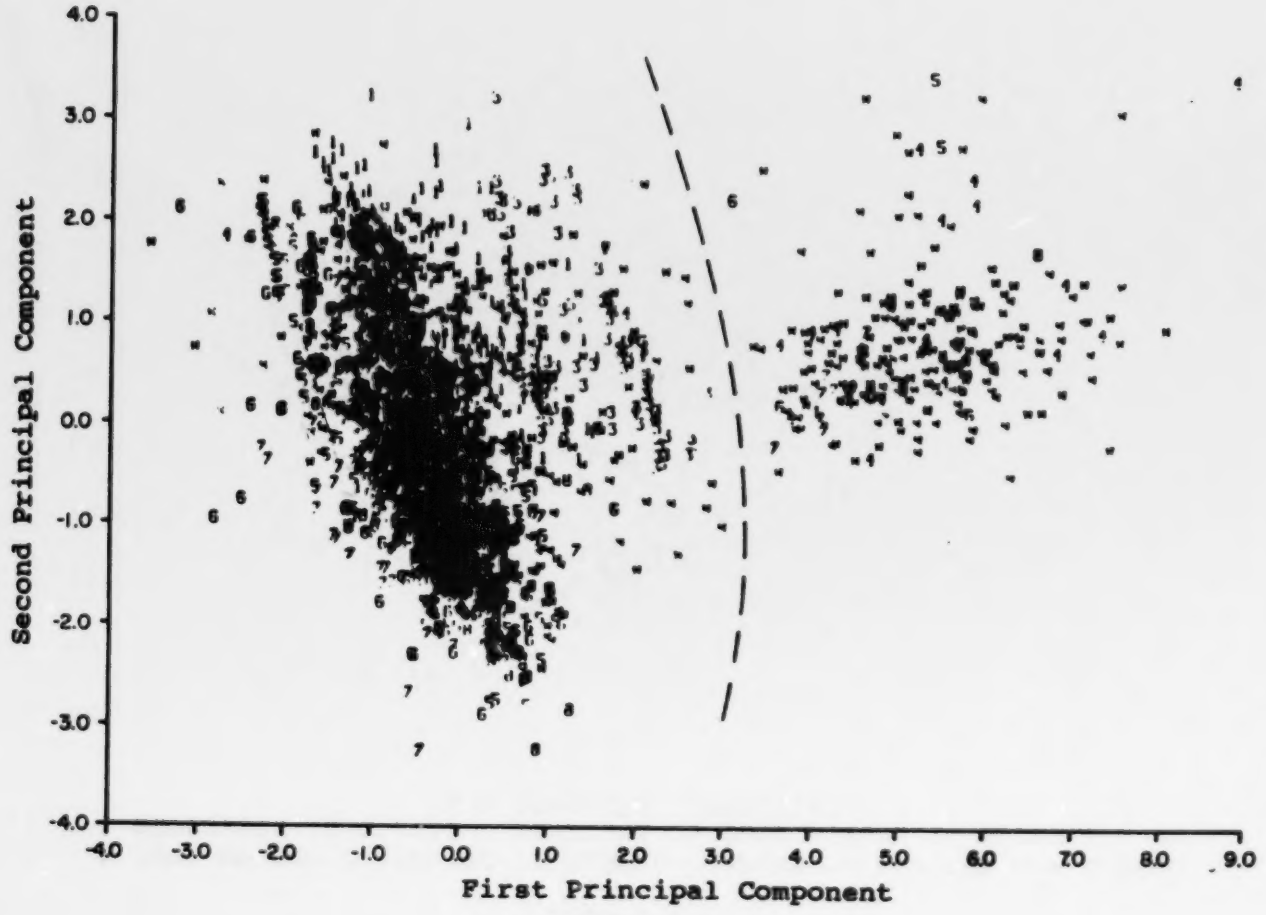


Figure A.10

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 1 962 SHIPMENTS IN QUÉBEC CONSISTING OF COMMODITIES IN GROUP V (END PRODUCTS, INEDIBLE)

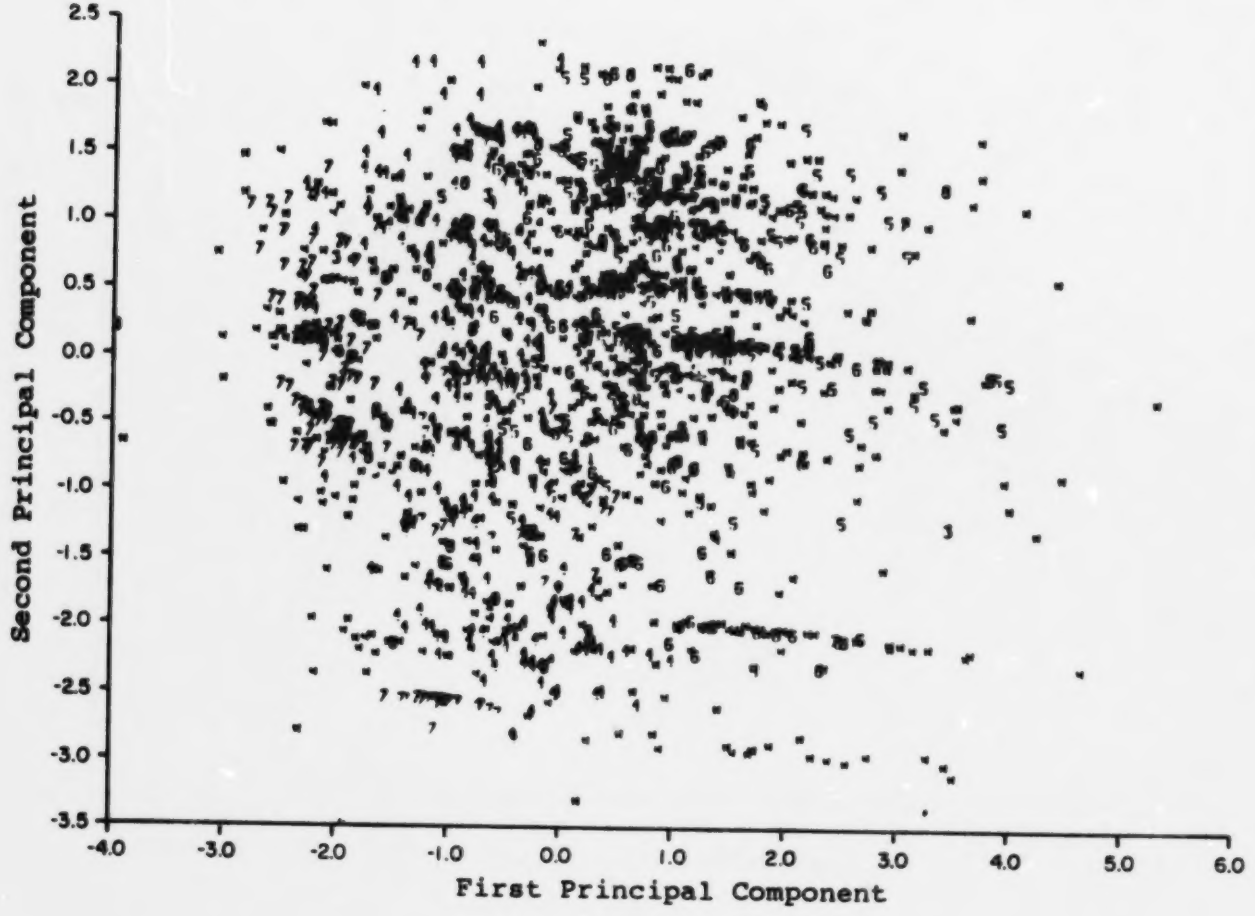


Figure A.11

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 1 100
SHIPMENTS IN ONTARIO CONSISTING OF COMMODITIES IN GROUP V
(END PRODUCTS, INEDIBLE)

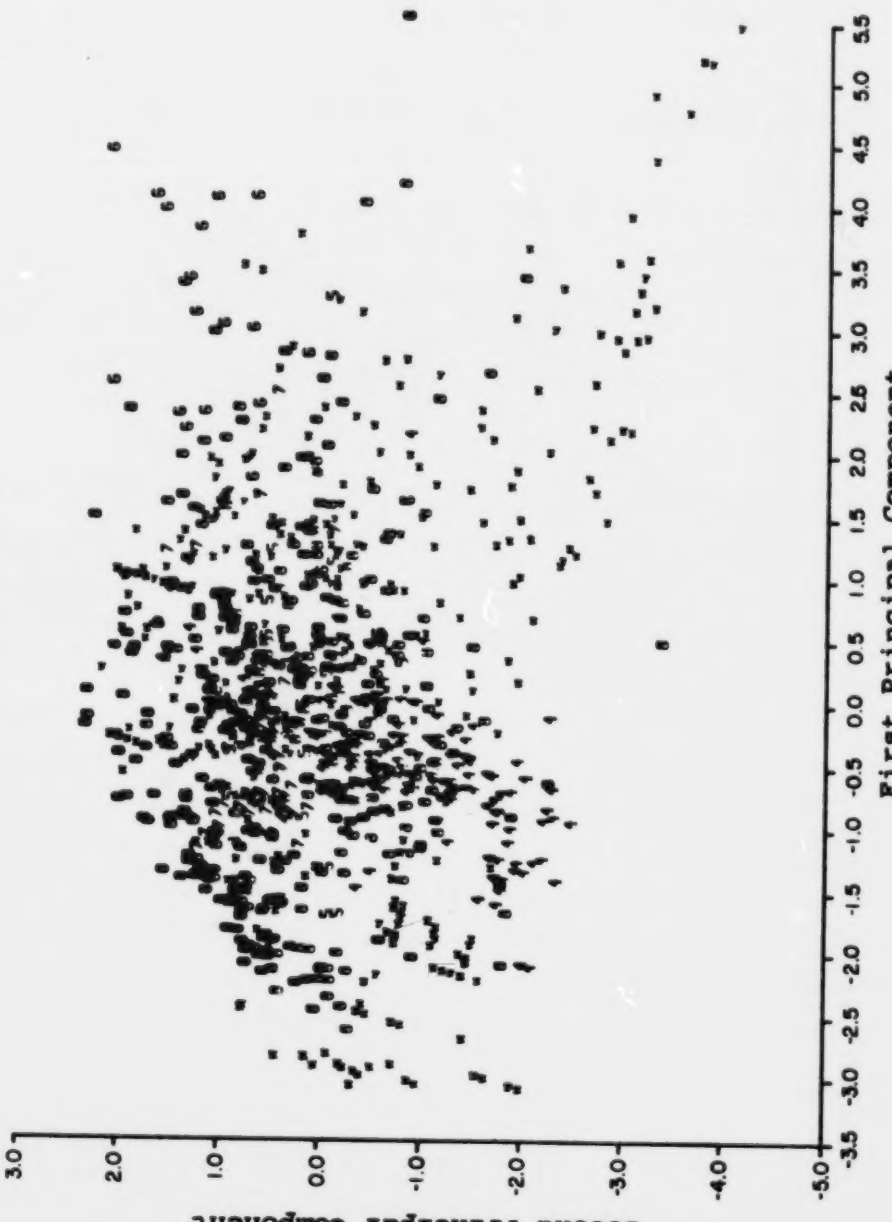
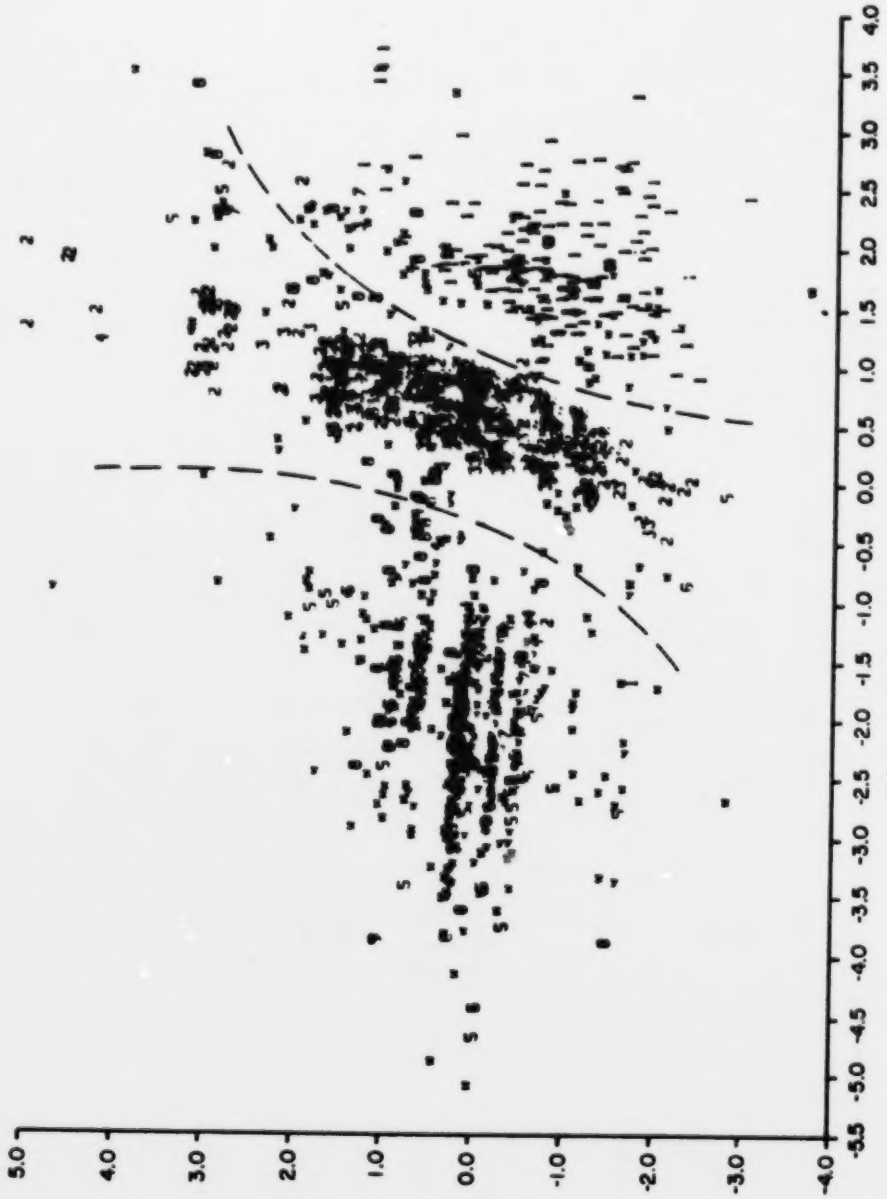


Figure A.12

A PLOT OF THE FIRST TWO PRINCIPAL COMPONENTS FOR THE n = 1 617 SHIPMENTS IN ALBERTA CONSISTING OF COMMODITIES IN GROUP V (END PRODUCTS, INEDIBLE)



Appendix C

TWO ALTERNATIVE METHODOLOGIES FOR THE MODELLING OF RELATIONSHIPS BETWEEN SHIPMENT STATISTICS

The universe or population of truck shipments under consideration in this study was the collection of truck shipments carried in 1975 by 103 carriers in the provinces of Québec, Ontario and Alberta for which a cost structure model was available.* Each carrier maintained shipment records at one or more Document Storage Location Points (DSLP) and a probability sample of shipment records was selected independently from each DSLP.

For each truck carrier c having one or more DSLP's designated by h, let the individual shipment records within a DSLP be designated by subscript i. Now let $Y_{hi}(\Omega,c)$ and $X_{hij}(\Omega,c)$ $j=1,2,\ldots p$ denote measurements associated with the shipment (hi) corresponding to the set of characteristics Ω for truck carrier c. By way of illustration we might define the set of characteristics to be general freight shipments or intraprovincial shipments in Québec. Two alternative methodologies have been proposed for the modelling of relationships between shipment statistics;** one methodology which will be referred to as method A disregards the sample selection scheme while method B takes explicit account of sample selection. A summary of these two approaches is given below.

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* For details see M.B. Cairns and B.D. Kirk, Canadian For-Hire Trucking and the Effects of Regulation: A Cost Structure Analysis, Canadian Transport Commission, Research Branch, Preliminary Report, (1979).

** For a recent survey of these and other methodologies see D. Holt, and T. Smith, Regression Analysis of Data from Complex Surveys. Paper presented at the Royal Statistical Society Conference, April 1979.

Method A

Suppose that each DSLP h provides n_h sampled shipments giving a total sample size of $n = \sum_h n_h$. According to method A, the sample selection scheme for shipments is disregarded and attention is restricted to measurements associated with the sampled shipments which will be designated $Y_{nhi}(\Omega,c)$ and $X_{nhij}(\Omega,c)$ $j=1,2,\ldots p$. If we consider the $(n \times 1)$ vector $\underset{\sim}{Y}_n = \{Y_{nhi}\}$ and the $(n \times p)$ matrix $X_n = \{X_{nhij}\}$ then a linear regression model of the form

$$\underset{\sim}{Y}_n = X_n \underset{\sim}{\beta} + \underset{\sim}{\varepsilon}$$

is assumed where $\underset{\sim}{\varepsilon} \sim N(\underset{\sim}{0}, \sigma^2 I)$. From familiar regression theory the parameters $\underset{\sim}{\beta}$ and σ^2 are estimated by

$$\underset{\sim}{b} = (X_n' X_n)^{-1} X_n \underset{\sim}{Y}_n$$

$$s^2 = \underset{\sim}{Y}_n' \left(I - X_n (X_n' X_n)^{-1} X_n'\right) \underset{\sim}{Y}_n / (n-p)$$

Furthermore, we have that

$$\underset{\sim}{b} \sim N(\underset{\sim}{\beta}, \sigma^2 (X_n' X_n)^{-1})$$

$$\frac{(n-p)s^2}{\sigma^2} \sim \chi^2_{n-p}$$

and the significance of the regression coefficient β_j may be assessed by examination of the corresponding t statistic

$$t = \frac{b_j}{s_{njj}}$$

where s^2_{njj} is the j^{th} diagonal element of $s^2 Q_n^{-1} = s^2 (X_n' X_n)^{-1}$.

Method B

Suppose now that each DSLP h contains N_h shipments giving a total population size of $N = \sum_h N_h$. The parameters of interest are defined to be the numbers B_j that minimize

$$\sum_h \sum_{i=1}^{N_h} (Y_{hi} - \sum_{j=1}^{p} B_j X_{hij})^2$$

If we consider the (N x 1) vector $\underset{\sim}{Y}_N = \{Y_{hi}\}$, the (p x 1) vector $\underset{\sim}{B} = \{B_j\}$ and the (N x p) matrix $X_N = \{X_{hij}\}$ then the solution of the above minimization problem is given by

$$\underset{\sim}{B} = (X_N'X_N)^{-1} X_N' \underset{\sim}{Y}_N = Q_N^{-1} \underset{\sim}{H}_N$$

where $Q_N = X_N'X_N$ and $\underset{\sim}{H}_N = X_N'\underset{\sim}{Y}_N$

Explicit recognition is now given of the sample design s through the inclusion probabilities $\pi(s)$. Define the random variables

$$T_{hi} = \begin{cases} 1 & \text{if the } i^{th} \text{ shipment is selected from DSLP h} \\ 0 & \text{otherwise} \end{cases}$$

where $Pr(T_{hi} = 1) = \pi_{hi}$ and consider the estimators

$$q_{njk} = \sum_h \sum_{i=1}^{N_h} \frac{X_{hij} X_{hik}}{\pi_{hi}} T_{hi}$$

$$h_{nk} = \sum_h \sum_{i=1}^{N_h} \frac{X_{hik} Y_{hi}}{\pi_{hi}} T_{hi}$$

If we consider the (p x p) matrix $Q_n = \{q_{njk}\}$ and the (p x 1) vector $\underset{\sim}{H}_n = \{h_{nk}\}$ then we have $E(Q_n) = Q_N$ and $E(\underset{\sim}{H}_n) = \underset{\sim}{H}_N$ where expectations are with respect to the probability sample $\pi(s)$. Therefore according to method B we consider

$$\underset{\sim}{b} = Q_n^{-1} \underset{\sim}{H}_n$$

as an estimator of $\underset{\sim}{B}$. We may rewrite the above estimator from method B, in order to compare it with the method A estimator, by considering the probabilities associated with the sampled shipments which will be designated π_{nhi}. Then

$$q_{njk} = \sum_h \sum_{i=1}^{N_h} \frac{X_{hij} X_{hik}}{\pi_{hi}} T_{hi} = \sum_h \sum_{i \in s} \frac{X_{nhij} X_{nhik}}{\pi_{nhi}}$$

$$h_{nk} = \sum_h \sum_{i=1}^{N_h} \frac{X_{hik} Y_{hi}}{\pi_{hi}} T_{hi} = \sum_h \sum_{i \in s} \frac{X_{nhik} Y_{nhi}}{\pi_{nhi}}$$

and so Q_n and $\underset{\sim}{H}_n$ may be expressed as

$$Q_n = X_n' W_n X_n$$

$$\underset{\sim}{H}_n = X_n' W_n \underset{\sim}{Y}_n$$

where the (n x n) matrix $W_n = \text{diag}\{\pi_{nhi}^{-1}\}$ and consists of the inverses of sampled shipment probabilities, or as they are frequently called, sampled shipment weights. Then the method B estimator may be expressed as

$$\underset{\sim}{b} = (X_n' W_n X_n)^{-1} X_n' W_n \underset{\sim}{Y}_n$$

Now it may be shown* that $\underset{\sim}{b}$ is asymptotically $N(\underset{\sim}{B},\Sigma)$ and that a consistent estimator of the covariance matrix Σ is given by

$$\Sigma_n = Q_n^{-1} G_n Q_n^{-1}$$

where the (p x p) matrix $G_n = \{g_{njk}\}$ and

$$g_{njk} = \frac{n-1}{n-p} \sum_h \frac{n_h}{n_{h-1}} \sum_{i=1}^{N_h} D_{hij} D_{hik} T_{hi}$$

$$D_{hij} = X_{hij} E_{hi}/\pi_{hi}$$

$$E_{hi} = Y_{hi} - \sum_{j=1}^{p} b_j X_{hij}$$

therefore the significance of the regression coefficient B_j may be assessed by examination of the corresponding approximate t statistic

$$t = \frac{b_j}{s_{njj}}$$

where s^2_{njj} is the j^{th} diagonal element of $Q_n^{-1} G_n Q_n^{-1}$.

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* For a theoretical discussion see W. Fuller, Regression Analysis for Sample Survey, Sankhya 37 Series C (1975), pp. 117-132.